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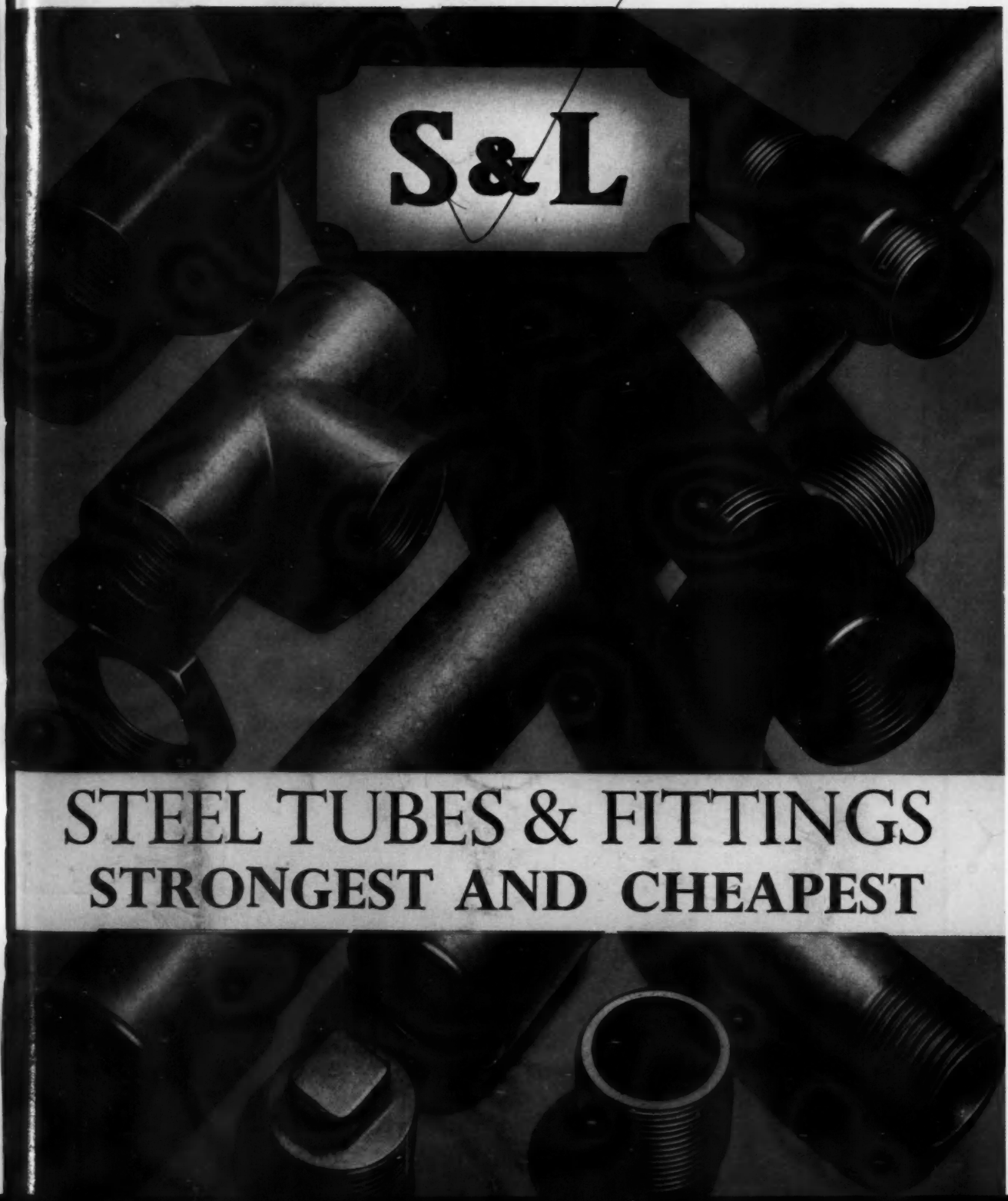

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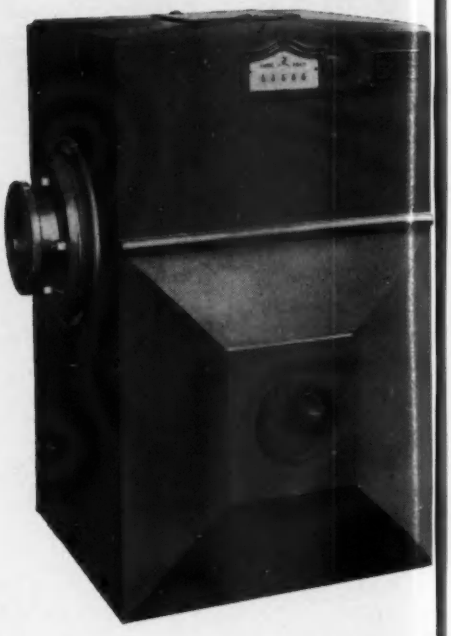

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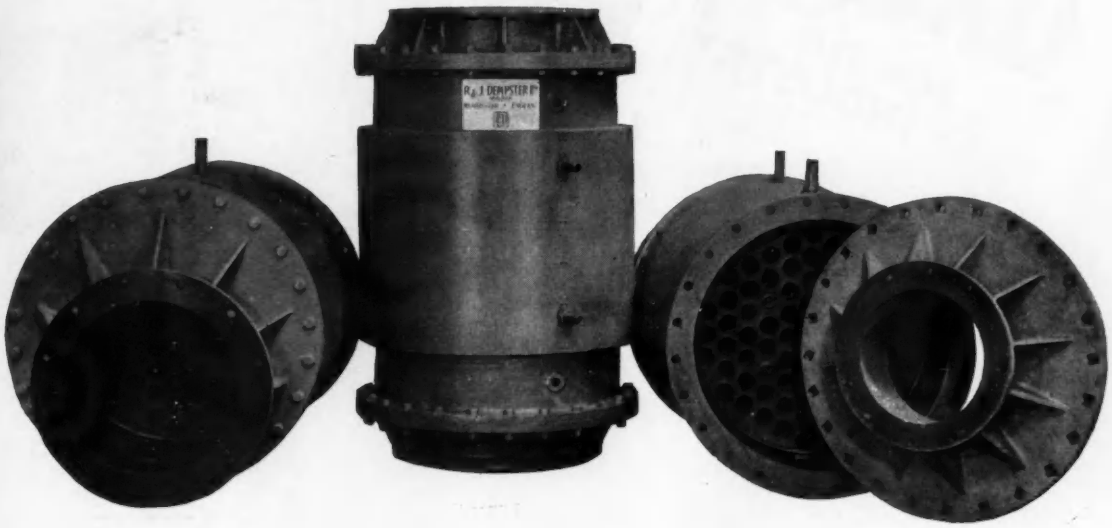

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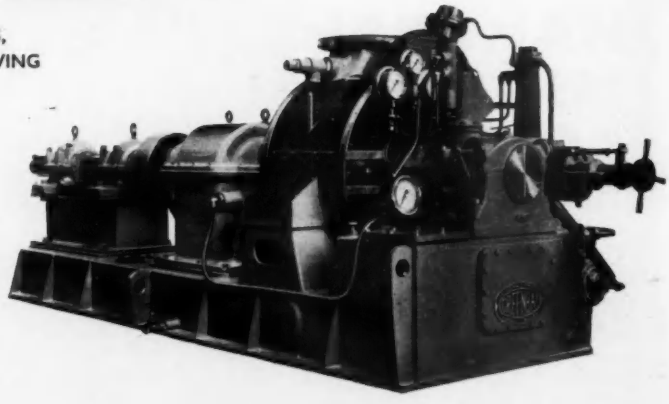

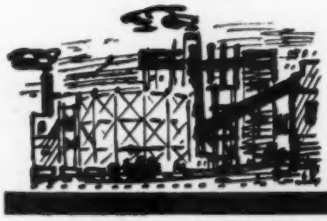

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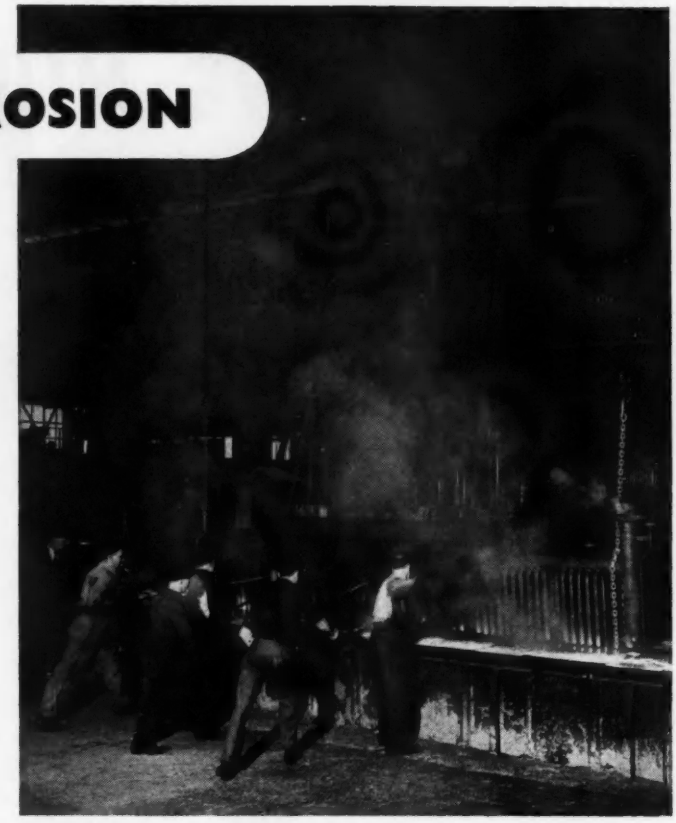

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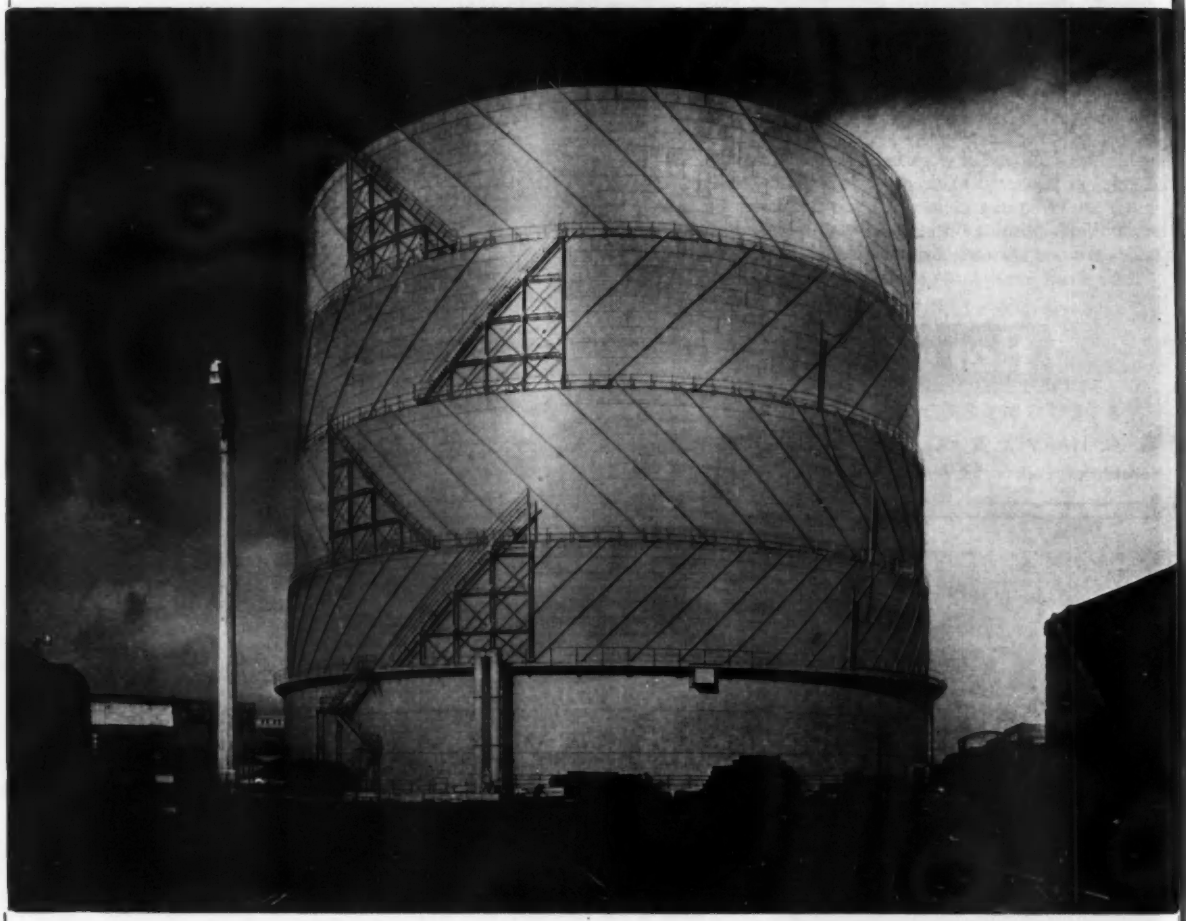

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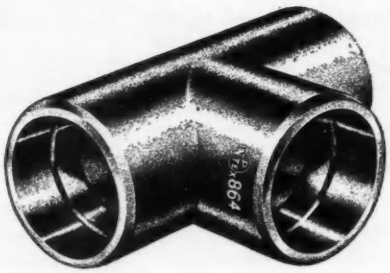

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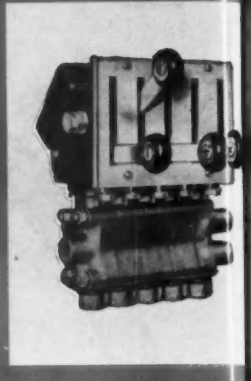

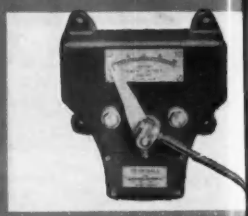

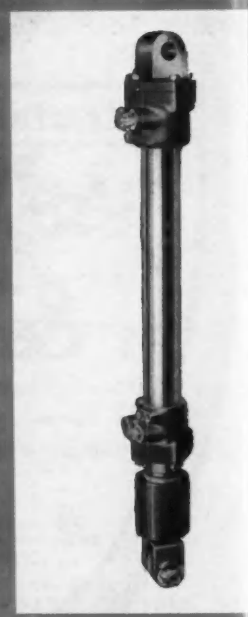

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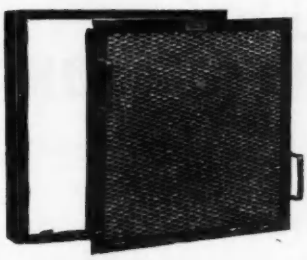

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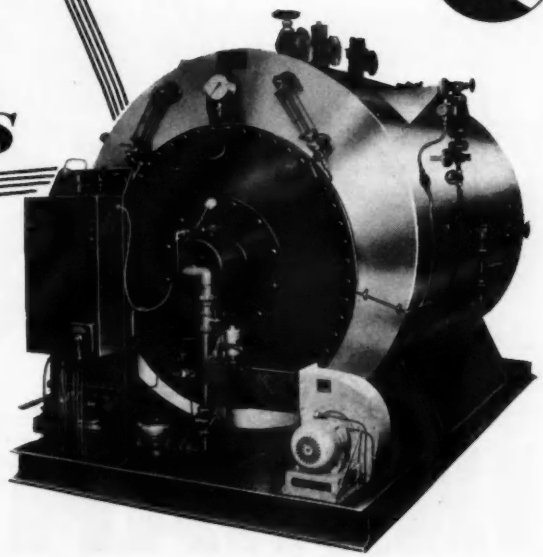

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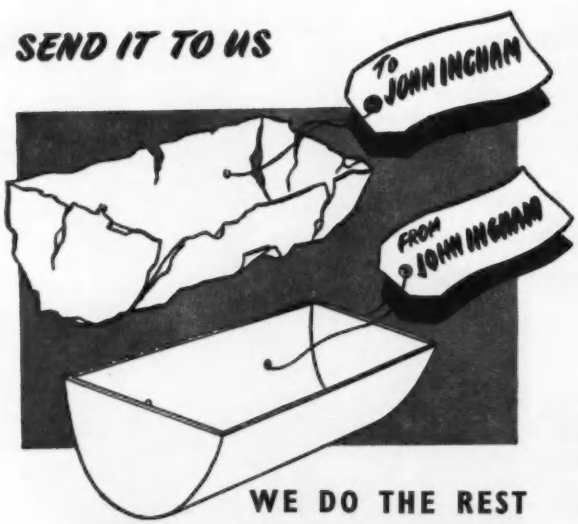

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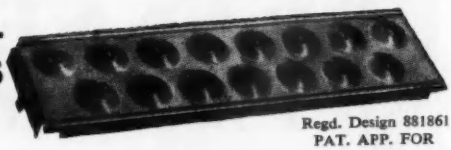

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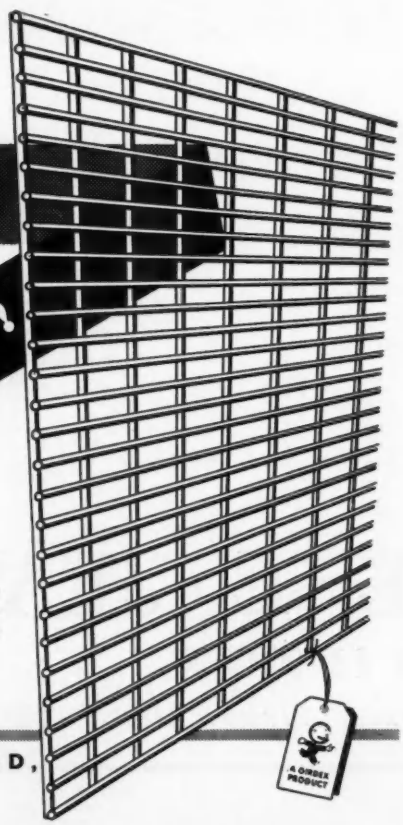

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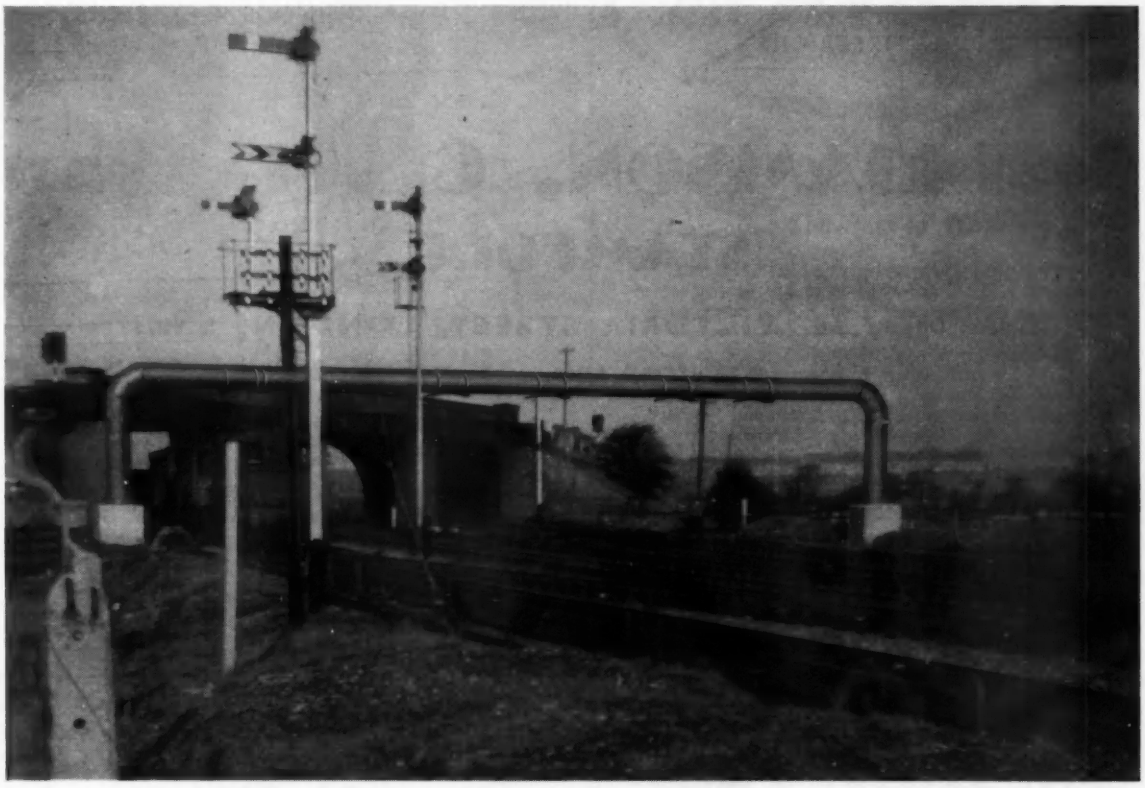

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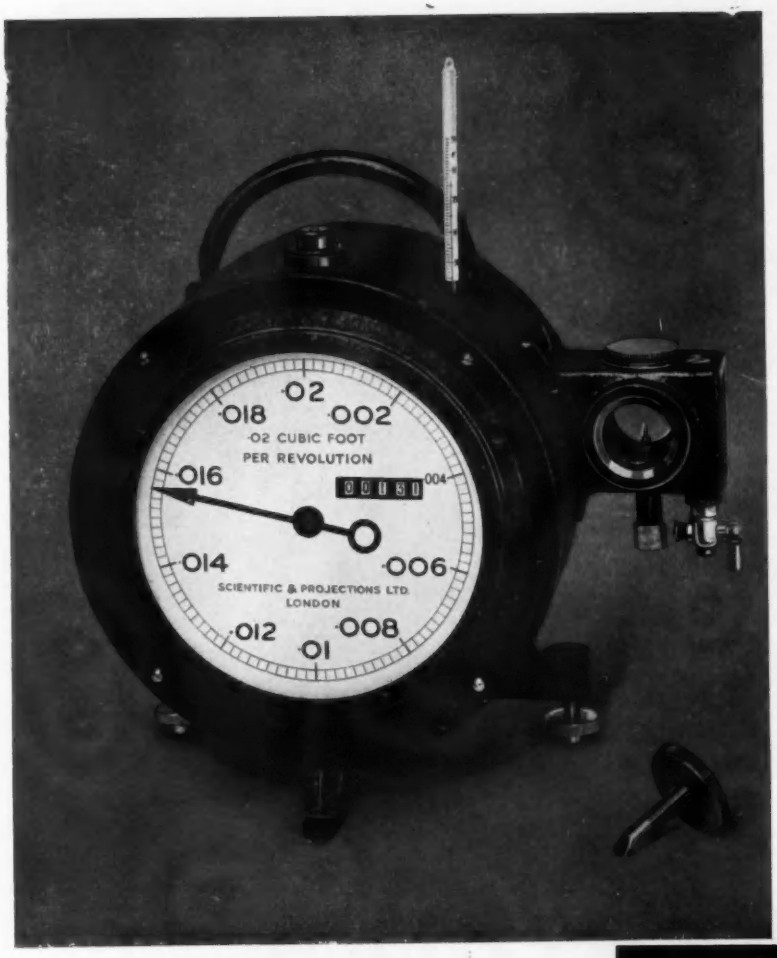

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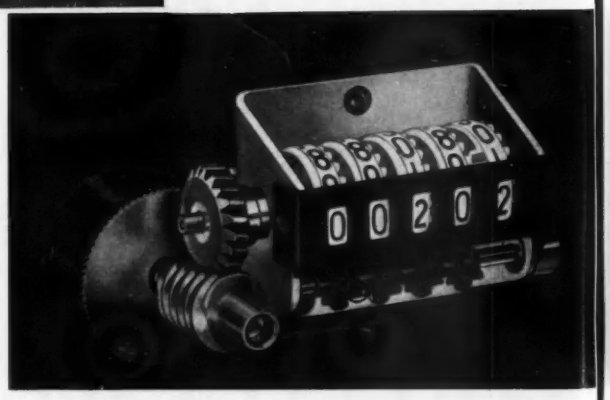

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Gas Journal

VOL. 291 NO. 4911 August 28, 1957

109TH YEAR

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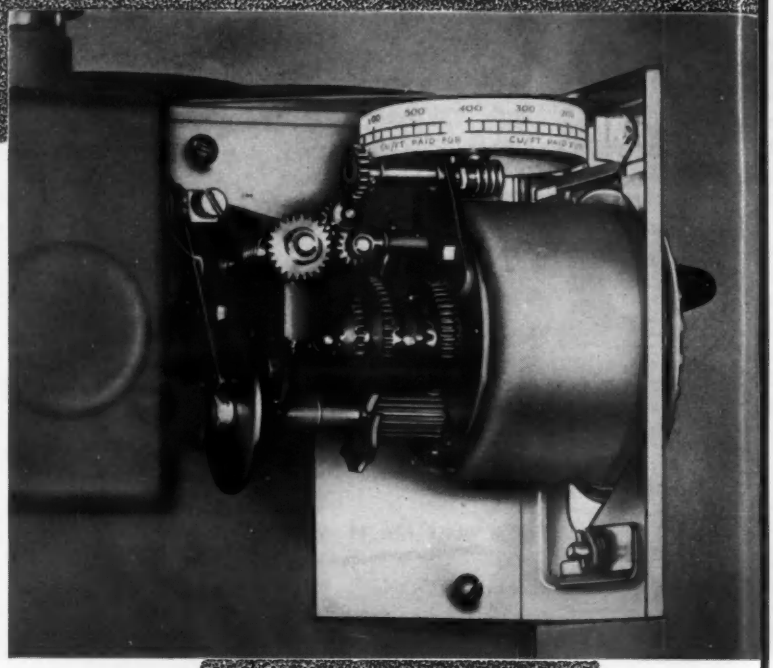
P/P mechanism with finger-tip control



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Gas Journal

VOLUME 291. No. 4911. AUGUST 28, 1957. 109th YEAR

Electricity in Gasworks

IT may seem something of a paradox that a periodical which circulates primarily among gas engineers to bring to their notice the latest developments in gas manufacturing plant and the latest theories and principles underlying gas production and utilisation, should devote an issue almost exclusively to electrical plant and how the gas industry is veering towards its use.

Perhaps 30, and most certainly 40 years ago, such an issue of the 'GAS JOURNAL' would have been impossible, and in the minds of some prominent members of the industry at that time would have seemed little short of heresy. In fact, cases are known where the prejudice against the use of electrical power in a gasworks was so great that considerable ingenuity was used to mechanise such plant as horizontal retort stoking machinery without the use of electricity when this was the best and most obvious source of power to use. Admittedly the earliest models may have used steam engines and small vertical steam boilers mounted in the stoking machine, but to design and make special hydraulic power operated machinery, would seem to be carrying one's war against the rival faction rather far. Since these mechanisms were well designed and extremely well made many of them may still be in use even today.

The idea of electric light in a gasworks would have been unthinkable at one time, but perhaps in this case the Engineer and Manager may be forgiven if his feelings on losing what was once the whole object of gas manufacture, the lighting load, made him loth to go over to the enemy and instal his rival's most dangerous commodity, however convenient it may have been and however beneficial to the running of the works.

Ever since the end of the first world war costs of manufacture in every sphere of activity have had the most tremendous effect on the carrying out of those activities and, as the years have passed, the most profound repercussions on the strength of the commercial position of any manufacturing enterpise, but it does not seem to have struck the gas industry quite as hard perhaps as some other industries until the second world war and its inevitable aftermath.

With the shortage and high cost of fuel, the gas industry's chief raw material, coal of a suitable quality and grading for carbonisation, began to become expensive and exceedingly difficult to get, the direct result of which was to put up both the price of coke to the consumer and the value of it to the gasworks.

In the days when both coal and coke were cheap, it was quite easy to raise steam for gasworks purposes in comparatively small medium pressure boilers at a reasonable cost. The steam was cheap to use as a source of power throughout the works and it did not matter too much if the losses in condensation in long pipe lines or in inefficiently maintained steam engines, were heavy. The steam engine is a comparatively simple piece of mechanism and the labour to keep it going, however wasteful the engine may have been in steam, was inexpensive, so that the urge to modernise the power units in many gasworks was not very great.

The idea of using electric power in gas and coke oven works, once suitable types of electric motors had been designed, had very obvious advantages, but such motors had to be safe in use and free from any danger of exploding air-gas mixtures which might be forming in the neighbourhood of exhausters and other machinery. It was necessary, too, to shield them from corroding fumes and the grit to be found near coke and coal handling plants. In the more isolated undertakings where the Central Electricity Board's central grid systems had not yet arrived, it would be necessary to generate the electricity on the gasworks itself, either by a gas engine using the undertaking's own gas or by steam engine using steam raised by Lancashire boilers fired by coke. Up to a point such a primitive type of set-up might be able to justify itself, but directly labour and fuel costs rose, the cost of raising steam would become prohibitive or the rise in the demand for gas could create peak load problems which might make it impossible to spare enough gas to run the generating plant at times when it was most wanted.

Some other means of raising steam must be used. With the extension and development of the continuous vertical retort after the first world war, the possibilities of raising adequate quantities of steam for gasworks

consumption by the utilisation of waste heat from these retort settings began to be investigated, and later was developed with a good deal of success. Steam raised by this means was cheap and in many cases made it possible to dispense with separate boiler installations. To gain the full advantage from the use of steam raised from waste heat, it would be necessary to centralise both its generation and its consumption. To centralise its generation was a simple matter by having one or more boilers in each retort house which, in a well designed modern plant, could all be grouped together in a separate carbonising area; but to centralise consumption it would be necessary to find some other means of transmitting power to prime movers throughout the works. The solution to this is electric generation at a centralised point and the conversion of all prime movers to electrical power. The electricity would be generated by pass-out or back-pressure turbo-alternators which would enable low pressure steam to become available for process work, space heating and domestic hot water as an amenity for the employees. The use of alternating current throughout the works would have the advantage of being interchangeable with high tension grid supplies in cases of failure of the works generator or of enabling excessive quantities to be exported.

Where the conversion of prime movers to electrical power is only partial, and such vital pieces of plant as exhausters and compressors as well as boiler feed pumps are steam driven, in the smaller gasworks especially, electric power will be purchased from the grid and not generated at all in the works despite the raising of waste heat steam, but in the larger works where turbo generators are installed, the production of electricity may be used only as a form of steam balancer. Here the main supply is really the grid system which is always in the background, with locally generated electricity there to be consumed when and in whatever quantity it happens to be available. If by any chance at times of peak activity there may be any excessive quantity of power available, this can be exported either to the distribution department for compressors and boosters or even, as in the case of the completely electrified works, back to the grid.

The raising of all or the major part of steam on the gasworks by waste heat recovered from the retort settings and, or alternatively, by the burning of breeze on specially designed grates in centralised boiler installations is now being universally adopted in all the modern gasworks which have been built since nationalisation. Where the size of the installation justifies it, electrical power will be generated in modern turbo-alternators. By this means power production will be at its cheapest and fully justify the heavy capital cost of the modern gasworks which employs conventional carbonising plant; at the same time it will go a little bit further towards the fuel economist's dream of employing the most suitable form of power from whatever source at the cheapest price, and as far as the gas engineer is concerned, be free from any of the prejudices which meant so much in the past.

The gas industry as we know it to-day is nearly a century and a half old and the general public are still in the habit of looking upon it as something old fashioned and inclined to the out-of-date processes of the nineteenth century.

The symbol of the gasworks for the layman is an enormous gasholder or as he often calls it quite incorrectly a ' gasometer,' unpleasant smells, and traditionally situated in the least attractive part of the town which it serves. The great advantages, however, to be derived from the use of gas in the household or factory make it possible for the inhabitant of the town to tolerate the presence of the gasworks.

Such an attitude is seldom found when the layman is talking about the electric power station. In his mind there is something new and up-to-date about the generation of electricity which is admirable and worth while pursuing. This may be due to the vast number of electrical appliances available to the man in the street for use in his home and the factory which will save him much manual work and make possible increased leisure.

This is a most unfortunate state of affairs which is wholly unjustifiable. The gas industry with great traditions behind it has been as ingenious in inventing and making use of current forms of power and machinery as any other industry, but the tremendous possibilities of the improvements in the amenities to be offered by the use and application of electrical power supplied a need which man had, perhaps unconsciously, been striving for for many centuries. Needless to say the source of power to provide these amenities got away to a flying start.

As soon as the impact of these benefits was fully realised, the gas industry, where it could, began to take advantage of them and, in fact, in isolated cases it first installed electric power in the early years of the century. By the very nature of things, however, electric power could not be installed in too great a hurry, since the early forms of equipment available were completely unsuitable for use in a gasworks. The presence of combustible gases capable of forming explosive mixtures in the vicinity of open direct-current motors, as so many were in the early days, was far too dangerous to be considered a practical proposition; the presence, too, of coal dust and coke dust was not entirely conducive to the economic maintenance of unprotected bearings and open copper commutators.

This was a challenge which had to be met both by the gas industry and the manufacturers of electrical equipment. As advances in engineering techniques progressed and more became known of the properties of inflammable gas-air mixtures, of the possibilities of new materials for the construction of electrical insulators and of the means of ventilation of suitably protected electric motors, so did the opportunities for the successful electrification of gasworks increase. Perhaps the pioneer in the use and development of the application of suitable equipment was the coke oven industry. Such plants were often owned by colliery companies which generated their own electrical power for use on the surface and would therefore have the necessary experience to try out and maintain any such equipment. Here, too, as these plants in the early days were not particularly interested in gas supply as such, there would be no prejudices or doubts as to the future of the gas industry.

With the evolution of suitable equipment and the spread of the grid supply of electricity, the installation of electrical power began to spread throughout the industry and by nationalisation in 1949 was well established. The greater areas of supply made possible by the setting up of the area boards increased the economic size of the gasworks which could be built and therefore assisted the application of the latest developments.

This has opened up enormous possibilities for the application of all the most up-to-date mechanical handling plant, the use of remote control and of electrical equipment similar to that in use in any other industry of equal size and importance to the community.

The gas industry no less than any other industry can now conjure with such phrases as 'push button factories' and 'the greatest possible degree of automation' and others, that are likely to fire the imagination of the younger generation. A modern gasworks need no longer be relegated to the slums because that happens to be the lowest part of the town both physically and socially, where the presence of dirt and smell are of rather less consequence.

In this issue an attempt has been made to describe some of the problems which face gas and electrical engineers in their combined efforts to adapt the standard equipment to the special conditions under which it has to be used in the gasworks. By illustrating many forms of equipment now in use, we have sought to show how modifications are being made to meet these special conditions both in design of power equipment and up-to-date forms of electric lighting which will conform to the safety standards demanded by the possibility of an explosive atmosphere. Such precautions will also apply to switchgear and control panels, which in addition to being specially protected are often sited in places remote from explosive or corrosive fumes. This assists in the siting of substations and central control points which lends itself to the most up-to-date and efficient systems of main feeders to give the minimum of power loss and the maximum precautions against failure of any one feeder by providing a ring main between substations.

The generating of power at high voltage makes for the efficient use of high powered electric motors for driving exhausters and large capacity compressors and boosters. Transformers, too, will be needed for a variety of purposes, to convert the incoming grid mains voltage to that locally generated if this should be different, to convert this high voltage to one suitable for medium powered drives and finally to low voltages for the safe working of portable tools and the use of inspection lights in boilers and other such enclosed places.

Personal

MR. H. E. ATKINSON, Divisional Manager of the Southern Division of the National Benzole Co. Ltd., since August, 1952, has retired, aged 65. Mr. Atkinson joined the National Benzole Company in 1923 as a junior representative in Sheffield and, in 1928, was promoted Sales Superintendent. Two years later he was appointed Assistant Divisional Manager, Southern Division, and his first promotion to Divisional Manager came in 1935 when he took over the Company's Northern Division in Newcastle. He was seconded to the Petroleum Board from the outbreak of war until 1946 when he returned to Sheffield as Divisional Manager.

MR. J. G. MCEWAN has been appointed Representative for Scotland by Dean Sales Promotion Ltd.

MR. ROBERT C. ARNOLD, former Manager of the Spalding works of the Eastern Gas Board, has left for Australia with his wife and family to take up a new appointment.

MR. D. F. CAMPFIELD has been appointed National Sales Manager, Photo Records Division, by Remington Rand Ltd.

MR. TOM HENDERSON, general foreman of the Kelty Division of the Scottish Gas Board, was presented with a wallet of notes recently on his retirement after 45 years' service in the gas industry.

Obituary

MR. SAMUEL CLAPHAM has died aged 71. Prior to his retirement in 1955, Mr. Clapham, who was Clerk to the Keighley Borough Justices, a partner in the firm of Waddington, Clapham and Feather, Solicitors, and a former President of Keighley Law Society, was also a Director of Clapham Bros., Ltd., gas plant makers.

U.K. GAS STOVES WILL BE SEEN AT GHENT FAIR

BRITISH gas stoves will be represented at this year's International Ghent Fair from September 7-22 by Cannon Iron Foundries, Ltd.

Both the Board of Trade and the Council of Industrial Design turned down official invitations to be represented at the Fair, the Board of Trade refusing the offer of a completely free stand.

On the other hand, many London, Midlands, and Scottish firms' manufactures will be on show. It is known that 21 British firms will be exhibiting, but the total number of British branded goods on show is likely to be in excess of last year's total of 60. The majority of British manufacturers not showing themselves, but leaving it to their Belgian agents.

Coke Prices Rise

In consequence of increased freight charges and distribution costs, advances in gas coke prices ranging from 2d. to 3d. per cwt. have been authorised and will come into operation on September 1 in the areas of the Eastern, North Thames, South Eastern, and Southern Gas Boards. These increases are in addition to the seasonal price variations for 1957-58, previously announced.

Correction

[We regret that tariff changes effected by the Eastern Gas Board were incorrectly attributed to the N.E.G.B. under the heading 'N.E.G.B. gives details of increases' on p. 372 of our last week's issue.]

Diary

September 3.—SOUTH EASTERN G.C.C.: Caxton Hall, Westminster, London, S.W.1. 11 a.m.

September 3.—EAST MIDLANDS G.C.C.: Victoria Station Hotel, Nottingham. 11.30 a.m.

September 13.—SCOTTISH G.C.C.: 26, Drumsheugh Gardens, Edinburgh, 3. 2.30 p.m.

Factory Equipment

The sixth Factory Equipment Exhibition will be held at Earls Court, London, next April 14-19. It will have as its theme: 'Modern Factory Equipment—Britain Challenges the World.'

Change of Name

The Hanwell Engineering Co., Ltd., of Northampton, has been taken over by Pollard Bearings, Ltd., and the title of the Company is now changed to Pollard Bearings (Northampton), Ltd.

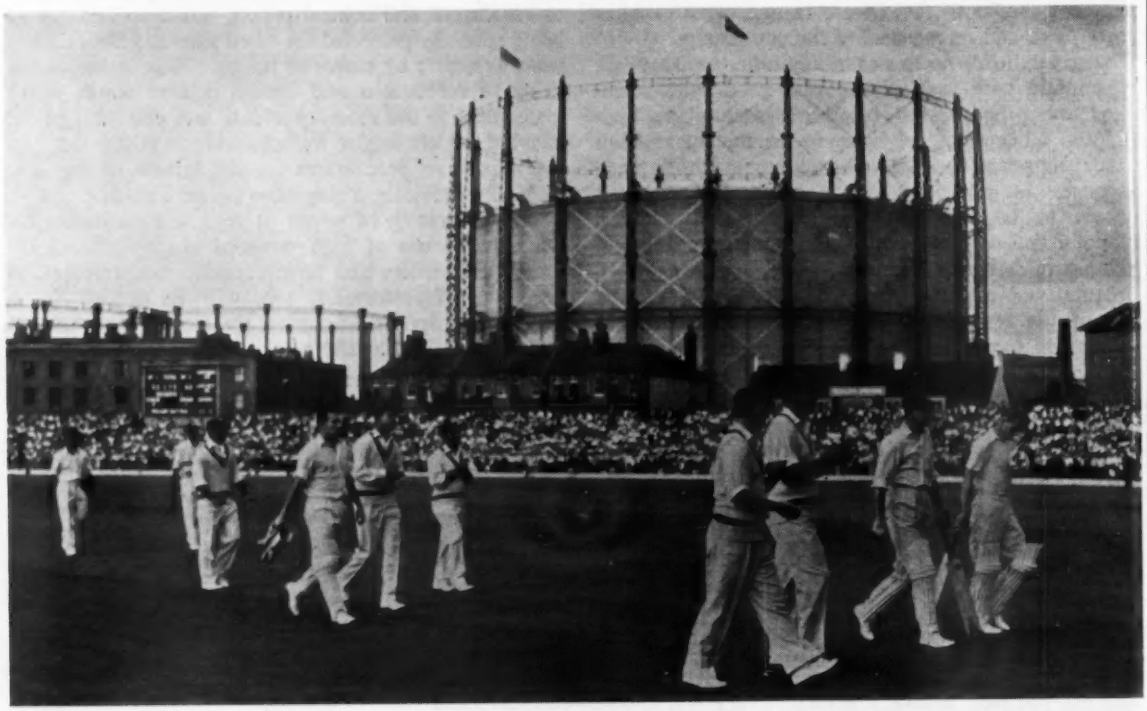
Separate Company

The George Kent Ltd. organisation in Belgium has been converted into a separate company under the title of Kent Continental, S.A., with headquarters at 82, Chaussée de Charlerio, Brussels.

Private Exhibition

The Dravo Division of Weatherfoil, Ltd., are holding a private exhibition of their heating equipment in Birmingham, at the Exchange and Engineering Centre, from September 24 to 26; and in Glasgow, at the East Room, McLellan Galleries, from October 1 to 3. The exhibition is expected to be of interest to architects, surveyors, heating engineers and all concerned with the heating of factories, multi-storeyed offices and flats, and large buildings or workshops.

The World's Most Famous Gasholder



The Oval 'gasometer'—world's most famous gasholder—background to the final Test Match between England and the West Indies. A new colour for the holder was adopted last year. It is a cheerful but unobtrusive blending of green and aluminium. Our picture shows (right—left) Richardson, P., and Graveney, the English batsmen, and Walcott, Goddard, Asgarali, Sobers, Alexander, Weekes, Worrell, and Kanhai, the West Indies fieldsmen, as they come in to tea on the first day of the match.

Doctor Urges Wider Use of Domestic Refrigerators

A PLEA for wider use of the domestic refrigerator has been made by Dr. Louis de Jongh, writing in the *Journal of the British Medical Association*. Personal and domestic hygiene **plus** refrigeration are needed to cut food poisoning cases, he says.

Unfortunately, far too few people own refrigerators, he continues. They say they cannot afford one; but still manage to buy a television set or a washing machine, or both.

'Yet a refrigerator is far more of a necessity. Somehow—possibly through the medium of that very television set—people must be made to see how, in their homes, they are the ones who can reduce the incidence of this dread disease.

'For it is a dread disease: It disables and it kills—especially the very young. It is a disease of ignorance, carelessness, and laziness. It must be overcome.'

Commenting, a Home Counties chief public health inspector stated:

'To my mind—and many colleagues agree with me—the average housewife is much dirtier than the average food shop assistant. She has absolutely no right to insist on food hygiene in the shop when she herself will not correct her dirty and dangerous habits.'

E.G.B. Tries Taking Out the Gas Bills by Hand

AS an experiment to test the possibility of the method as a means of saving postal charges, the Eastern Gas Board has been delivering accounts direct to consumers by hand in one district of North London during the past two months.

The practicability of the scheme has been demonstrated, said Mr. R. H. Epps, Secretary of the Board recently. They would soon look at it from the economic point of view, he added. They hoped to save 'some thousands of pounds.'

The London Electricity Board have been conducting similar experiments.

B.T.H. SECURE £100,000 DOLLAR ORDER

A CONTRACT valued at nearly £100,000 for the largest blast furnace turbo-blower supplied by the Company for installation overseas, has been secured by British Thomson - Houston, Ltd. The order, which also includes condensing plant, is for the Algoma Steel Corporation of Canada and was received through British Thomson-Houston Co. (Canada), Ltd.

The plant is normally rated at 85,000 cu.ft. per minute, 30 lb.-per-square-inch gauge; but will be capable of dealing with the maximum volume of 100,000 cu.ft. per minute at a discharge pressure of 20 lb.-per-square-inch gauge.

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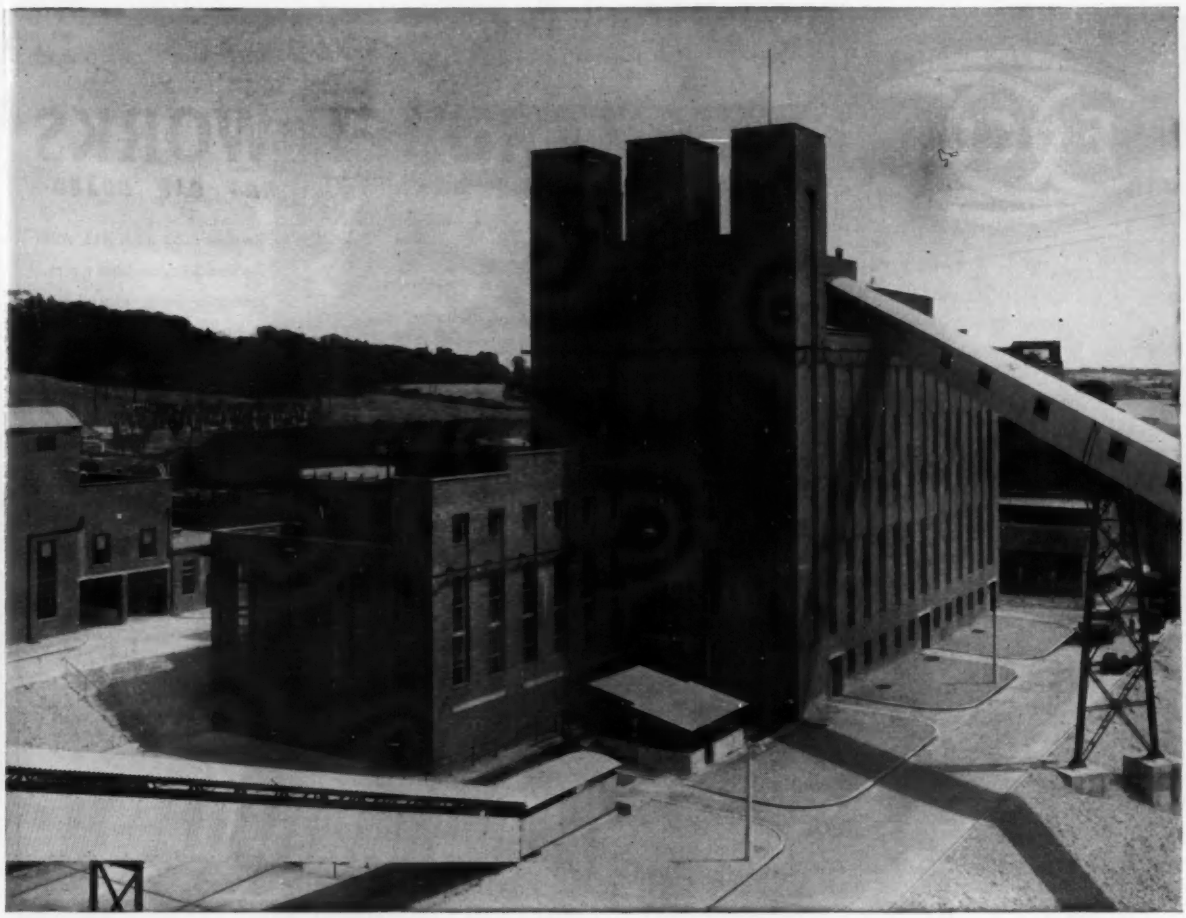

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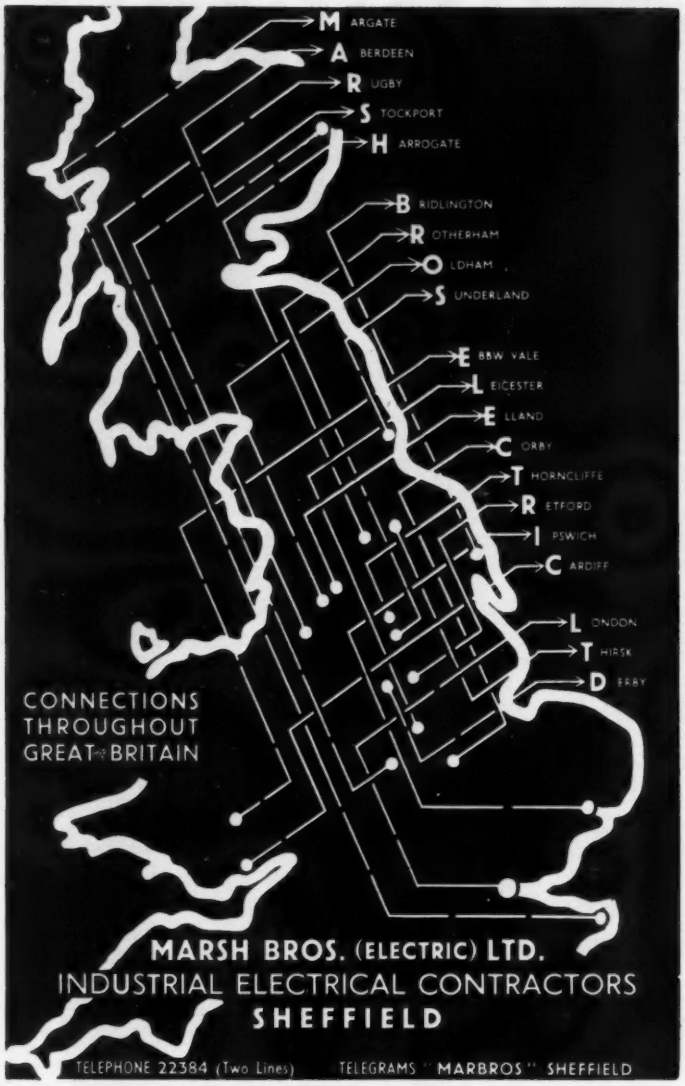

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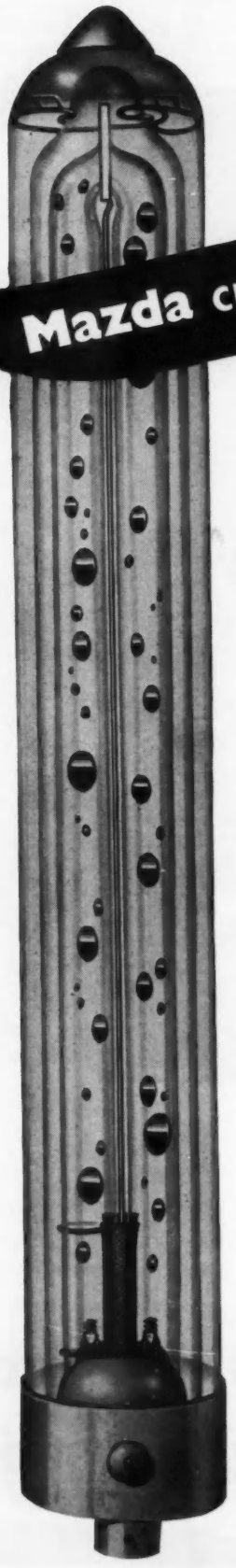

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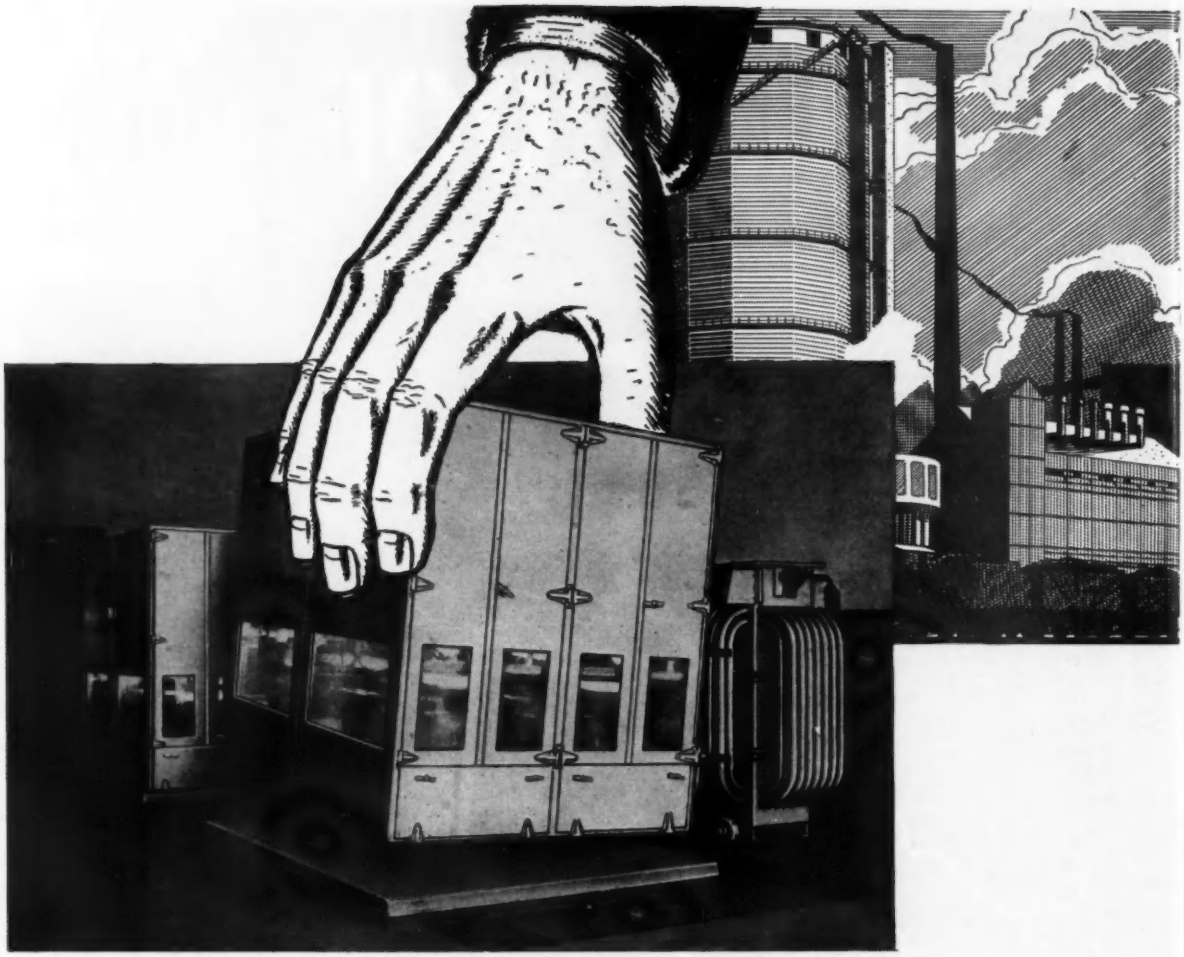

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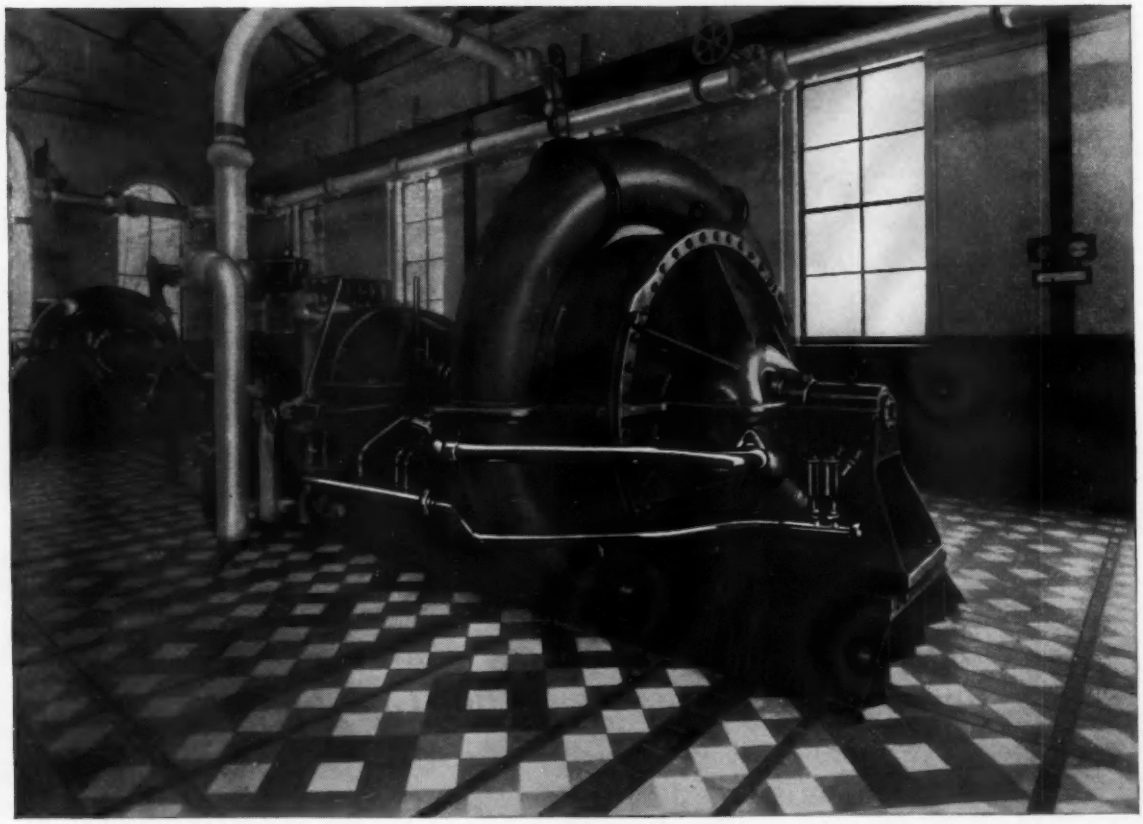

BTH manufacture turbine and motor-driven centrifugal compressors, blowers, boosters and exhausters of various capacities. This BTH turbine-driven gas booster is installed at the Fulham works of the North Thames Gas Board; it is rated for continuous service at 2,000,000 cubic feet per hour.

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Steam-raising in the Retort House

APART from the use of the recuperator or generator, and even after them, there is a substantial quantity of waste (or residual) heat which is profitably recovered in the retort house. Mr. L. J. Clark in his paper 'Steam and Power in the Gas and Coke Industry' (following Dr. Pexton and others) remarked that while the first consideration for efficient recovery is to return as much heat as possible to the manufacturing process, when this has been done there is still a large surplus.

In the design of the continuous vertical retort the use of conventional recuperation between setting and chimney has been abandoned. But it is to be noted that, even in this type of plant, a considerable quantity of residual heat is used within the system. Products of combustion leaving the combustion chambers proper are circulated around the tops of the retorts giving up heat to the incoming charges of cold coal. Secondary air is circulated around the bottom sections of the retorts absorbing heat from the out-going coke, apart from the use of much of this heat in raising the temperature of the injected steam to the point where water gas is produced.

Dr. Pexton estimated that the sensible heat in the waste gases leaving the continuous vertical retort setting should raise 13.6 lb. of steam (from and at 212°F.) per therm of gas made, while for intermittent vertical and horizontal retorts after recuperators there should be 10.5 and 10.0 lb. respectively. Yet Mr. Clark is able to say that, in the North Thames Area, 'The works with the lowest power costs has a modern CVR installation of 8 mill. cu.ft. per day capacity, and although the fuel consumption of this plant is less than 10% of the coal throughput, it produces sufficient waste-heat steam to supply over 75% of the total works demand, including the requirements for power generation.'

For the carbonising process, as for every other where furnace heating is concerned, there is a minimum temperature of the flue gases at the exit from the setting, below which they cannot be allowed to fall without an adverse effect upon the process. This temperature will vary somewhat according to the type and construction of plant, the characteristics of the coal carbonised and of the products, but it represents an irreducible surplus of heat necessarily rejected from the setting. This surplus is a considerable and valuable fraction of the amount of heat generated from the fuel used for underfiring. It should always be thought of in relation to the heating system as a whole, as something to be recovered and applied with the maximum of economy, lest its established, but deceptive, name of 'waste' heat cause it to be treated as 'something for nothing.'

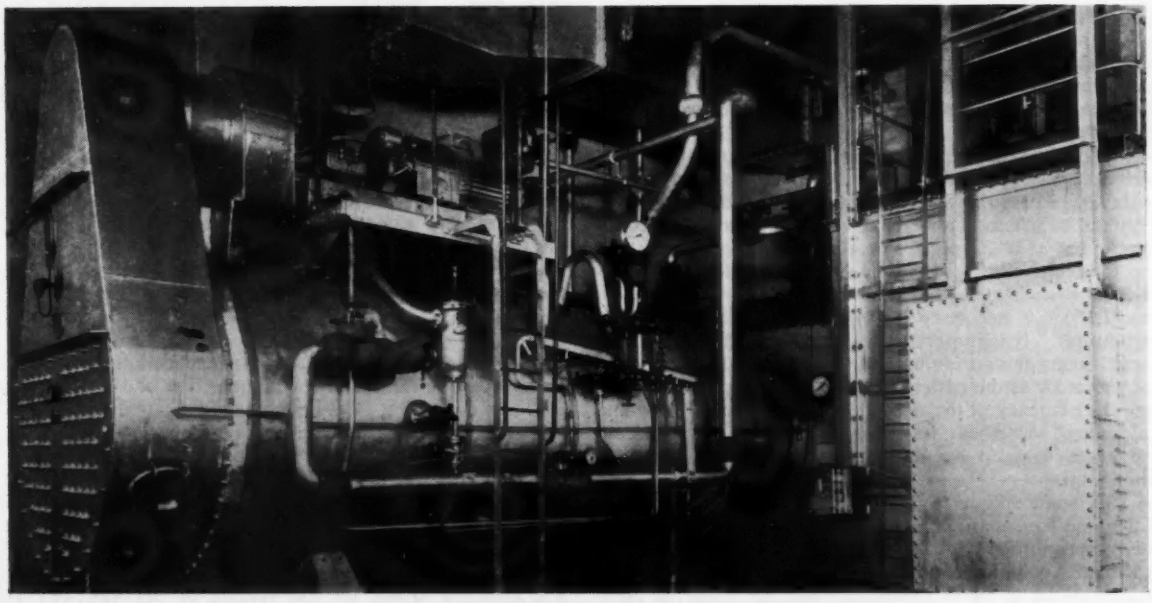
From continuous vertical settings the temperature of the exit gases is commonly 950 to 1,000°C. In most intermittent vertical and horizontal retort settings a part of the heat of the flue gases is recovered in recuperators in the setting itself, the temperature at the exit flue probably being between 450 and 500°C.

As a typical example it is proposed to estimate the sensible heat in exit gases at 1,000°C. from a vertical retort setting under-fired as usual by coke in a step-grate producer. The factors involved besides temperature are the volumes and specific heats of the constituent gases.

In an actual case in which the producers were of the pressure-operated step-grate type the producer-gas analysis showed a variation over a twelve-hour period between cleaning times from, at its best, 5.4% CO_2 and 27% CO down to, just before cleaning the fire, 8.2% CO_2 and 21.3% CO.

The average complete analysis worked out in round figures to the following:

CO_2	.. ..	7%
CO	.. ..	25%
H_2	.. ..	10%
CH_4	.. ..	0.5%
N_2	.. ..	57.5%
		100.0%



One of six Spencer-Bonecourt waste-heat boilers on the Howden C.O.L. plant.

TABLE I

GASEOUS PRODUCTS OF COMBUSTION OF PRODUCER GAS GENERATED FROM 1 LB. OF COKE
Containing 0.88 lb. fixed carbon and yielding 82 cu. ft. of producer gas at the analysis shown.

Case No. :	1	2	3	4	5
Proportion of excess air	Nil	20%	50%	100%	150%
Volume of secondary air cu. ft.	72	72	72	72	72
Volume of excess air cu. ft.	—	14	36	72	108
Total air used cu. ft.	72	86	108	144	180
Volume of flue gases cu. ft. (excluding 'adventitious' water vapour)	140	154	176	212	248
Volumetric analysis of flue gases	%	%	%	%	%
WET CO_2	19.0	17.3	15.2	12.6	10.7
H_2O	6.5	5.9	5.1	4.3	3.6
N_2	74.5	74.9	75.4	76.0	76.5
O_2	—	1.9	4.3	7.1	9.2
	100.0	100.0	100.0	100.0	100.0
DRY CO_2 (i.e. as measured)	20.4	18.4	16.0	13.1	11.1
N_2	79.6	79.5	79.5	79.4	79.4
O_2	—	2.1	4.5	7.5	9.5
	100.0	100.0	100.0	100.0	100.0

The gas was obtained from coke containing 88% of 'fixed' carbon, and 82 cu.ft. of producer gas of the above-mentioned analysis would be generated from 1 lb. of such coke; it would require 72 cu.ft. net of secondary air to yield, by perfect combustion, 140 cu.ft. of flue gas, all volumes being measured at 0°C. With the producer-gas analysis at its best the volume of products work out at 136 cu.ft. and just before cleaning to 141 cu.ft. per lb. of coke consumed. The volume of flue gases per unit weight of fuel obviously does not vary much with the periodic changes in the composition of the producer gas, so an estimate of their heat content may reasonably be based upon the composition of the average sample.

Only exceptionally, however, will the gases leaving the setting be the net products of combustion. In practical cases they will usually contain excess air, a fraction of which may be air supplied in excess of requirements to the combustion chambers, but the major part of which is invariably due to infiltration into the setting in those portions of the circulating flues which are under vacuum, through such accidental entries as cracks and leakages in the brickwork, etc.

For the present purpose of estimating the amount of heat carried away from the setting it will be assumed that in an average case the flue gases at the exit from the setting contain 20% excess air. The volume leaving the setting (measured at 0°C.) per lb. of coke consumed would then be 154 cu.ft. Whatever volume of flue gas leaves the setting must leave at the temperature (in this case assumed to be 1,000°C.) necessary to maintain good carbonising conditions. It is important to realise that the amount of heat leaving the setting unused increases as the proportion of excess air at the outlet from the setting increases, reducing the efficiency of the setting itself even though providing additional waste-heat for recovery. Every effort should be made to keep excess air at the settings exit to a minimum.

This point will be clearer from Table I in which the foregoing figures are tabulated with volumes resulting from higher proportions of excess air. The table also shows the calculated volumetric analysis of the flue gases, both 'wet' (i.e., containing the H_2O vapour resulting from the combustion of hydrogen) and 'dry' (i.e., with such vapour condensed). The former analysis is the one required for subsequent calculations of heat content, but the latter corresponds to the analysis obtained in practice with the 'Orsat' type of apparatus. The table demonstrates the fact that the CO_2 content so measured is a practical indication of the amount of excess air present. In practice the amount of air indicated by a particular CO_2 content of the products of combustion of producer gas varies somewhat, being affected by the hydrogen content of the producer gas and by accidental factors, but this variation is seldom wide enough to affect the usefulness of the indication. Compare, for instance, with Table I, another typical example worked out for a retort setting by Captain W. Gregson; for 0, 50, 100 and 150% of excess air he obtained 19.5, 15.5, 12.9 and 11.1%, respectively, of CO_2 in the dry waste gas. The chief accidental factor peculiar to retort settings, causing divergence of flue gas analyses from their theoretical proportions, is leakage of coal gas into the combustion flues. When such leakages occur they in fact augment the heat available in the flue gases, though in reducing thermal output from the retort, they reduce overall efficiency.

There is another factor, neglected in Table I, which increases the volume of the flue gases. A certain amount of water vapour from the primary air, from moisture in the coke, from water on the grate plates, or from injectors, always passes through the producer fuel bed undecomposed. It receives a slight increase from moisture in the secondary air and leaves the setting necessarily at the same temperature as the other exit gases, the sensible heat content of which it therefore increases. The amount of steam passing through the fuel bed undecomposed will be variable, being related to the composition of the producer gas, but depending also upon operating conditions. Dr. Pexton quotes a test on an open step-grate producer which showed 4.2 volumes of H_2O vapour in 100 volumes of dry gas. Test figures before the writer at the moment show 3.25% for a step-grate pressure producer to which air was supplied by a centrifugal fan. Rather more would be expected from a steam-blown producer. Assume for the present typical example that water vapour in the producer gas amounts to 6% on the volume of dry gas, i.e., to $6\% \times 82 = 4.9$ cu.ft. per lb. of coke. The moisture entering

the setting with the secondary and excess air depends, of course, upon atmospheric conditions. Tables show that it would amount to 1.74% of the volume if the atmosphere were fully saturated at 60°F. Assuming the atmosphere to be 75% saturated, then for the present example the amount of moisture carried in by secondary and 20% excess air, per lb. of coke, would be 75% × 1.74% × 86 = 1.1 cu.ft. The total 'adventitious' moisture in the exit gases would then by 4.9 + 1.1 = 6 cu.ft.

That is to say, the volume previously calculated of 154 cu.ft. of exit gases per lb. of coke would be increased to 160 cu.ft. or by less than 4%. The sensible heat of this vapour would be in slightly greater proportion due to its greater specific heat, but by an amount negligible in the present estimate. It may be concluded, therefore, that 'adventitious' water vapour in the flue gases at the exit from the setting represents an increase probably of the order of 4% on the heat content of the gases calculated on dry producer gas and air. As this increase is small and variable it will be neglected in subsequent calculations. But it is never absent, and represents a small reserve on the results.

We proceed, therefore, upon the basis of Case 2 in Table I.

'Many determinations of the specific heats of individual gases have been made, but the results, particularly at high temperatures, are in some cases very conflicting. It is now believed that the most accurate data are the so-called theoretical values calculated from the spectroscopic characteristics of the gases. For this reason, theoretical values are presented' (Technical Data on Fuel, 4th Edition, p. 115). In Table II the mean specific heats are converted from the metric values tabulated in 'Technical Data.'

Using the 'wet' analysis from Case 2 in Table I the sensible heat content (above 0°C.) per cu.ft. of exit gases from the setting is as calculated in Table II.

TABLE II

	Volume cu. ft.		Mean spec. heat		Range of temperature 0°C		Sensible heat B.Th.U.	Sensible heat content %
CO_2	0.173	×	0.0596	×	1,000	=	10.3	24.6
H_2O	0.059	×	0.0460	×	1,000	=	2.7	6.5
N_2	0.749	×	0.0375	×	1,000	=	28.1	67.1
O_2	0.019	×	0.0397	×	1,000	=	0.8	1.8
Flue gas	1.000	×	0.0419	×	1,000	=	41.9	100.0

Sensible heat of flue gas per lb. of coke consumed = 154 cu. ft. × 41.9 B.Th.U = 6,450 B.Th.U.

The mean specific heat of the flue gas (0.0419 B.Th.U. per cu.ft. at 0°C.) is, of course, obtained by dividing the total of the sensible heats column by the temperature. Comparison of the last column with the volumetric analysis shows the effect of the higher specific heats (as compared with N_2 & O_2) of CO_2 and H_2O.

This, then, is the quantity of heat leaving the setting. But the whole of it cannot be recovered. A fraction will be dissipated from the surfaces of the flues. A more considerable fraction must be discharged in the gases at the waste-heat boiler outlet, of which the 230°C. usually repre-

TABLE III

HEAT RECOVERABLE FROM FLUE GASES
PRODUCER FROM 1 LB. OF COKE
(To be read in conjunction with Table I)

Case No. : (compare with Table I)	3		4		5	
EXCESS AIR						
At setting outlet (case 2, Table I)	20%		20%		20%	
At boiler inlet	50%		100%		150%	
VOLUME (v) of FLUE GAS at 0°C. 760 mm.						
At setting outlet cu. ft.	154		154		154	
At boiler inlet ,, ,,	176		212		248	
ACTUAL VOLUME of FLUE GAS at T°C.						
At setting outlet cu. ft.	718		718		718	
At boiler inlet ,, ,,	728		779		825	
At boiler outlet ,, ,,	324		391		457	
TEMPERATURES T°C.						
At setting outlet	1,000°C.		1,000°C.		1,000°C.	
At boiler inlet (to nearest 5°C.)	855°C.		730°C.		635°C.	
At boiler outlet	230°C.		230°C.		230°C.	
MEAN SPECIFIC HEATS (c)						
B.Th.U. per cu. ft. per °C. for range 0 to T°C. and for volume measured at 0°C.						
At setting outlet	0.0419		0.0419		0.0419	
At boiler inlet	0.0408		0.0396		0.0388	
At boiler outlet	0.0375		0.0371		0.0368	
SENSIBLE HEATS, B.Th.U. (VxcxT)	B.Th.U.	%	B.Th.U.	%	B.Th.U.	%
At setting outlet	6,450	100	6,450	100	6,450	100
Less 5% radiation loss etc. from flues	320	5	320	5	320	5
At boiler inlet*	6,130	95	6,130	95	6,130	95
Less at boiler outlet	1,520	24	1,810	28	2,100	33
Total recoverable in steam	4,610	71	4,320	67	4,040	62
STEAM OBTAINABLE						
lb. from and at 212°F.	4.75		4.46		4.16	
lb. actual at 100 lb. per sq. inch gauge and 50°F. of superheater from feed water at 60°F.	3.88		3.64		3.4	

* Neglecting the small sensible heat of the additional infiltrated air, about 15 B.Th.U. in case 3 and 66 B.Th.U. in case 5, at 20°C.

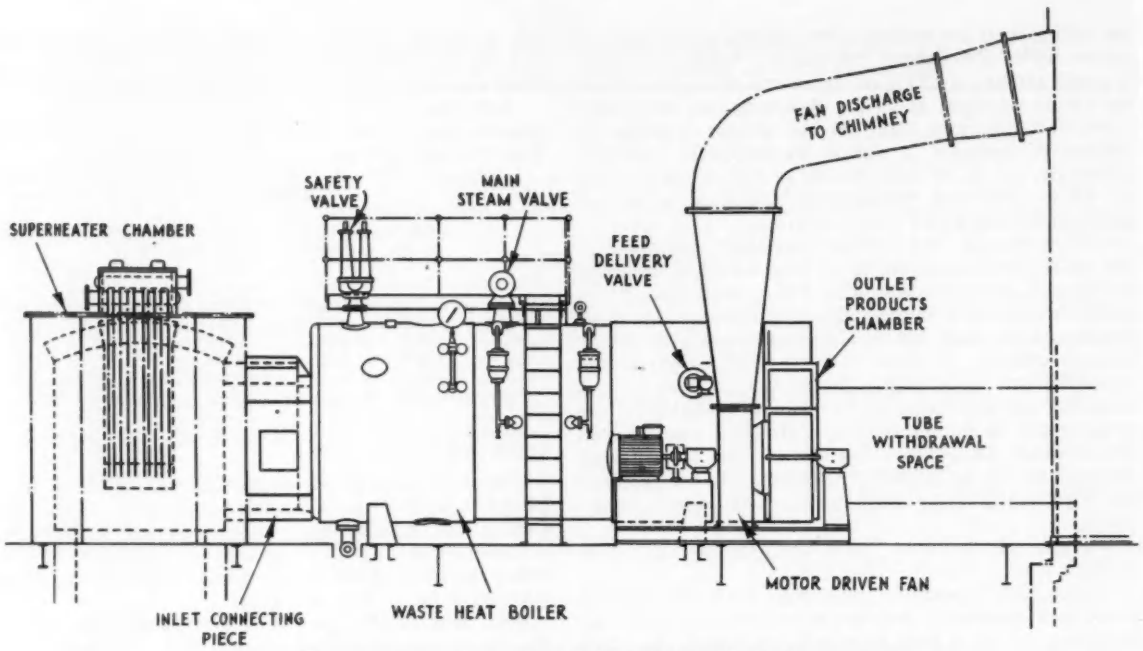


Fig. 1. Schematic diagram of waste-heat boiler installation fitted with superheater.

sents about the practical minimum temperature. The greater the volume of the gases discharged from the boiler at this temperature, the greater the amount of heat carried away to waste. Air leakages into the flues between the setting outlet and the boiler inlet should, therefore, be kept to a minimum. Some infiltration, however, is inevitable, a part of it being even necessary to reduce the temperature of the gases at the boiler inlet to the safe limit set by metallurgical and other practical considerations. For instance, the temperature of 1,000° here assumed at the setting outlet would be too high, for regular working, at the inlet tube plate of most waste-heat boilers unless practically perfect feed water were available, i.e., that the possibility of scale formation, which allows overheating of the front tube plate and tube ends, were avoided.

Table III completes the typical example under consideration. It shows the calculated amounts of steam recoverable in three cases in which the excess air contents of the flue gases have increased to 50%, 100% and 150% respectively at the boiler inlet. A number of calculations on the lines of Table II, involving a certain amount of trial-and-error work in arriving at specific heats and temperatures at the boiler inlet, are involved in the compilation of a table of this kind, and no useful purpose would be served in showing them in detail.

Some of the figures in Table III bring out points mentioned in the last paragraph but one. Although in each case there is the same amount of heat available at exit from the settings, the proportion which is recoverable drops from 71% to 62% as infiltration to the flues increases the excess air content at the boiler inlet from 50% to 150%, and steam production correspondingly decreases. The important factors at the boiler inlet are both temperature and volume, the latter for practical purposes being indicated by a CO_2 content. Thus (comparing Tables I and III) in case 4 the temperature of 730°C., at the boiler inlet is associated with a CO_2 content, as measured, of 13.1%, and about 4½ lb. of steam (from and at 212°F.) is obtainable. But if the same temperature were associated with a CO_2 content of, say, 16% (case 3) a deficiency of volume (or, more correctly, of heat) would be indicated, and the same steam production could not be obtained without an increase of temperature.

The weight of steam recoverable 'from and at 212°F.' is obtained, of course, by dividing the total recoverable B.Th.U. by the latent heat of steam at 212°F., under atmospheric pressure, i.e., 970 B.Th.U. per lb., and the actual weight by dividing the total recoverable B.Th.U. by the total heat of steam, as obtained from tables (and corrected for feed-water temperature) under the actual steam-raising conditions of pressure and superheat (in the case given in Table III, H = 1,189 B.Th.U. per lb.).

The amount of steam obtainable per lb. of coke varies from 4.75 lb. from and at 212°F. in case 3 to 4.16 lb. in case 5. As a matter of fact, about 4.9 lb. of steam from and at 212°F (or about 4 lb. actual at 100 to 120 lb. per square inch gauge pressure) per lb. of coke consumed can usually be obtained from vertical retort settings, and is frequently guaranteed.

Calculation of the amount of heat available for steam-raising purposes is not fundamentally different, of course, for any type of setting, due regard being had to the particular temperatures and volumes concerned. From gases leaving the recuperators of horizontal settings at 480°C. Captain W. Gregson states that 2.8 lb. of steam from and at 212°F. are obtainable per lb. of coke, assuming about 200% of excess air because infiltration in such cases is considerable.

The section of Table III relating to flue gas volumes shows them corrected to 0°C. (which is necessary for purposes of comparison, and for the calculation of specific and sensible heats) and also actual volumes at the temperatures concerned. In any consideration of gas velocities in the flues or tubes the actual volumes are, of course, involved. The velocity in the tubes is a matter for the boiler designer. About velocities in the flues it is difficult to generalise. They should not be so high as to induce excessive resistance, which increases the load on the boiler fan, increases the amount of air infiltration to the flues owing to the higher vacuum within them, and, especially if the flues are long, may occasion considerable difficulty in evacuating gases from the parts remote from the fan. On the other hand they should not be so low as to necessitate too large a flue, which is inconvenient, expensive, and unsightly, and also has excessive external surface area for radiation and convection losses. Waste-gas flues external

to the setting may be designed for a maximum gas velocity of 40 ft. per second, with the boiler on normal rated load.

The areas of long flues receiving successive increments of flue gas from a series of setting outlets should be graduated as much as may be practicable, not merely to save constructional material, but to reduce inequalities of flue gas velocity and resistance.

The waste-heat boiler generally used is the horizontal induced-draught tubular boiler with the gases passing through the tubes at a high velocity to secure turbulent flow. It is within almost common knowledge that Osborne Reynolds and Nicolson have shown that when fluids pass through a tube at moderate velocities the molecules tend to travel in parallel lines, so that only the outer molecules in the stream actually come into contact with the walls of the tube. Under such conditions the heat transfer in a long tube is independent of the velocity of the stream. When, however, the velocity is increased beyond a certain critical figure (of the order of 40 ft. per second for flue gases at 800°C. in a 1½-in. boiler tube) turbulence is set up and all the molecules are brought into contact with the heat-absorbing surface. The rate of heat transfer is much greater and it increases with the velocity of the stream. The adoption of this principle in the case of waste-heat recovery is the more important, because heat transfer at the comparatively low temperature available in the waste gases from retort settings must take place by contact and not by radiation. The waste-heat boiler, therefore, is designed to obtain the greatest possible direct contact between the molecules of the waste gases and the heat absorbing surfaces, this object being attained by the use of a large number of small diameter tubes through which the gases are drawn at the highest possible velocity consistent with power economy and with the provision of straight tubes which can be readily inspected and cleaned. These then are the principles upon which the design of the Spencer-Bonecourt boiler, which has been very widely used in the retort house, is based (see I.Gas E. Comm. No. 113, 1935).

The normal waste-heat boiler is fitted with an induced-draught fan which deals with the pull on the settings, in addition to the resistance of the boiler unit; in other words, the plant as a whole is entirely independent of chimney draught for its operation. The flue system is normally of steel-cased construction, lined with insulating brick and firebrick in order to reduce radiation loss. The steel casing eliminates the infiltration of cold air, which not only reduces the effectiveness of the waste gases as a steam-raising medium, but also increases the load to be handled by the induced-draught equipment. The gas-tightness of the flue system is readily measured by comparing the CO_2 readings (a) at the offtake from the settings, and (b) at the boiler. These readings give a direct measure of the excess air content in the gases at the points where measured. The usual Orsat analyses should, therefore, be periodically carried out at these two points as a check. A CO_2 recorder connected to the boiler intake is a useful addition to the equipment.

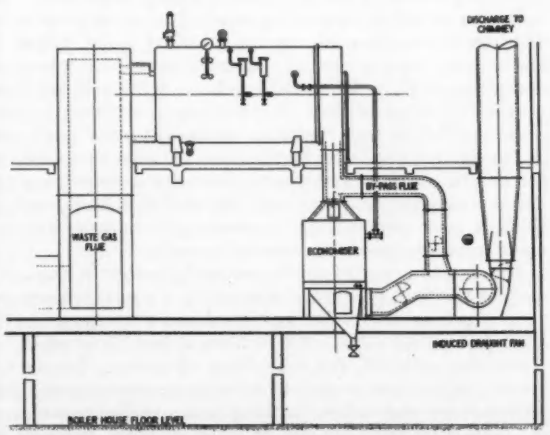


Fig. 2. Elevation of waste-heat boiler with economiser.

The draught on the settings is normally fixed by regulating the fan speed to suit the normal load. In the case of electrically-driven units working on direct current, this is done with a shunt control, and in the case of steam-driven units, by the governing adjustment. Any further slight variations can be met from time to time by the hand-wheel adjustment which is coupled up to the regulating dampers in the discharge throat of the fan. This avoids the necessity of resetting the actual fan speeds for small variations in control.

Where alternating current motors are supplied to drive the fan at constant speed, the whole range of draught control is carried by the fan dampers. The draught required at the intake of the boiler varies, according to the adjustments of the settings outlet dampers, from two to five tenths. It should not be more than just that necessary to take away the products of combustion from the settings.

Positioning

Waste-heat boilers should be placed as near as possible to the waste-gas outlets from the retort bench in order to cut down flue work with its attendant first cost and potenial heat losses. Fan discharge flues to atmosphere should also be kept as short as possible to safeguard the steel-work from corrosion at the comparatively low temperature at which the gases leave the fans. In a long length of steel exhaust flue, corrosion, due to the condensation of sulphurous acid, would have to be guarded against. If trouble of this nature does occur, practice has shown that the best means of preventing excessive cooling is to lag the outside of the outlet flue with 2½ in. to 3 in. of 85% magnesia composition. Care should be taken that the whole flue system is kept in good condition, in order to avoid the two sources of heat loss mentioned above—loss by radiation and loss by infiltration of cold air.

The horizontal boiler, which has been the most widely used, is fitted with straight tubes which are normally 1½ in. internal diameter and 15 ft. 6 in. long, and the mean velocity of the gases through the tubes varies from 70 ft. to 110 ft. per second, at which speed the dust is carried over and does not tend to clog up the tubes.

A certain amount of manual cleaning is, however, necessary. This can be effected without closing the boiler down, through a suitable disposition of removable plugs on the cover plate of the outlet box of the boiler. The tubes are rodded with suitable scrapers while the outlet chamber is illuminated by an air-cooled electric lamp fitting. In addition, the intake (superheater) boxes are fitted with hoppers through which periodic charges of coarse wood chippings are thrown. These chippings are drawn through the tubes by the action of the induced draught, and can generally be relied upon to scrape the surfaces perfectly clean. Wet steam does more harm than good as it tends to clog the dust and form a cement like deposit which has to be removed afterwards by the scrapers.

Steam raised in the retort house is generally lightly superheated, i.e., 50° to 100°F. above saturation temperature. Superheaters are of the radiant-heat type, with detachable elements, arranged at the inlet end of the boiler out of the flow of the gases because of the relatively high temperature of the gases at this point.

The driving of the induced-draught fan varied with local circumstances, two systems being in general use:—

(a) Direct-coupled to pipe-ventilated dust-proof electric motors.

(b) Direct-coupled to geared steam-turbines.

In the case of steam drives, the usual practice is to exhaust from the turbine to a surface-type heater which recovers the bulk of the heat units in the exhaust steam, returning it to the boiler by way of the ingoing feed. The feed-water heater is placed on the delivery side of the pumps, in order to avoid any possibility of pump failure by hot suction, and is provided with a by-pass which allows it to be opened up for cleaning without shutting down the feed supply to the boiler.

Being of the tubular type, the waste-heat boiler requires good feed-water, and care should be taken that little more than 2° hardness is present. In cases where heavy softening is necessary, it is desirable to fit a continuous blow-down arrangement in order to avoid over-concentration of treated feed in the boiler. Such over-concentration leads to the formation of large bubbles on the water surface, priming, and the deposition of salts in the pipe lines.

The boilers are arranged with the tubes nested to facilitate internal access and to ensure that the tubes can be not only inspected but cleaned on the water side. Tubes are expanded in to the tube plates at each end of the boiler, beaded over at the inlet ends and belled at the outlet ends, and should any leakage occur it is normally rectified by a little light rolling with the expanders. On the other hand, it is even more important to remove the cause of the leakage, i.e., to prevent scaling, which is always more acute at the inlet or hotter end of the boiler where evaporation of the greater proportion of the water takes place.

Boilers are always fitted with automatic feed water regulators which, in the case of single boiler units, control the steam to the pump, and in the case of multiple boiler installations operate on the delivery to each boiler. As a safeguard to the automatic feed, a high and low water alarm whistle is also fitted to each boiler, and the water capacity of each unit is sufficient to give plenty of margin for the retort house charge-hand to get to the boiler plant to rectify any simple defect, or alternatively, to change over the pumps, before the danger point is reached.

Until recently it was considered that a waste-heat boiler designed for a maximum working pressure of 120 lb. per sq. in. would meet the requirements of practically all gasworks. There was seldom call for other than dry steam at the main points of usage, which could be ensured by superheat limited to 50° to 100°F. In recent years, however, higher pressures and temperatures have been called for. The limiting pressure for the conventional cylindrical boiler appears to be about 300 lb. per sq. in., but working pressures of 250 lb. per sq. in. and total steam temperature of 600°F. are not uncommon.

The theoretical and practical considerations influencing the choice of steam pressure and temperatures in waste-heat recovery are outlined by Mr. T. Nicklin (North Western Gas Board) in a paper presented to the Manchester Juniors in December, 1949. For steam pressures of 300 lb. per sq. in. and over it is necessary to provide an economiser to heat the feed-water and to reduce outlet gas temperature to an economic limit. The outlines of the design used at Denton are shown in Fig. 2.

Higher pressures will demand heavier scantlings and different methods of construction; continued improvement in welding technique will no doubt solve the problems involved in the construction of boiler drums to withstand higher working pressures.

The choice of steam pressure to be adopted will be influenced by many factors; they should not be adopted just because they are within the limits of practicability. Each case should be considered on its own merits.

Such a consideration is well set out in a paper presented to the S.W. Section of I.Gas E. in March, 1954, by Mr. J. Parker in which he discusses the reasons for the selection for the new works at Bristol, of a pressure of 250 lb. per sq. in. and a total steam temperature of 600°F. (see GAS JOURNAL, March 24, 1954, p. 743). These conditions could be reached without any fundamental departure from conventional design and therefore without any significant increase in capital cost per unit of production.

High-efficiency Turbo-alternators

IN the past the efficiency of steam turbine-driven machinery in gasworks has been of secondary importance owing to the large amounts of steam made available from waste heat. It has been, and still is, the practice in many gasworks to drive auxiliaries by inefficient single-stage steam turbines exhausting to atmosphere. The present high cost of coal and the need to conserve national reserves has, however, focussed attention on the need for economy in all industries, and in the gas industry the most effective course is undoubtedly to utilise all steam in high-efficiency turbo-alternators and to drive as many of the auxiliaries as possible electrically. The excess electrical power which is usually made available can then be sold to the public electricity supply authority, provided that the turbo-alternator is arranged to run in parallel with the public supply mains which is an essential condition. The demand for steam at low pressure for retort steaming and by-product recovery plant is usually less than the waste-heat boiler capacity for producing high-pressure steam, so that a pass-out condensing turbine which can absorb the excess boiler steam is almost always required.

Apart from actual turbine design considerations, there are two major factors which contribute to the efficient operation of turbo-alternators for gasworks service. They are inlet pressure governing and automatic nozzle control.

It will be appreciated that as steam is normally generated in a gasworks by waste-heat boilers there will be no control over the quantity of steam available, so that with the system described it is clear that the satisfactory governing of the turbine will present certain problems. The normal method of controlling steam flow to suit electrical demand cannot be used, as restriction of boiler output is intolerable. In any case, the conventional speed governor cannot be used, as the speed of the machine will be fixed by the frequency of the outside supply to which it is connected. The primary function of the governor gear, and of the turbine itself for that matter, must be therefore, to extract the maximum amount of electrical power from the steam available, and the only thermodynamically sound solution is to provide inlet pressure governing and automatic nozzle control in association with it.

The function of the inlet pressure governor is, by controlling the flow of steam, to maintain a constant pressure at the turbine stop valve and therefore a constant maximum heat drop across the turbine, a condition which is absolutely essential for maximum efficiency. Incidental but important advantages of the arrangement are that the turbine is prevented from robbing vital auxiliary machinery of steam, and priming due to reduced boiler pressure is prevented.

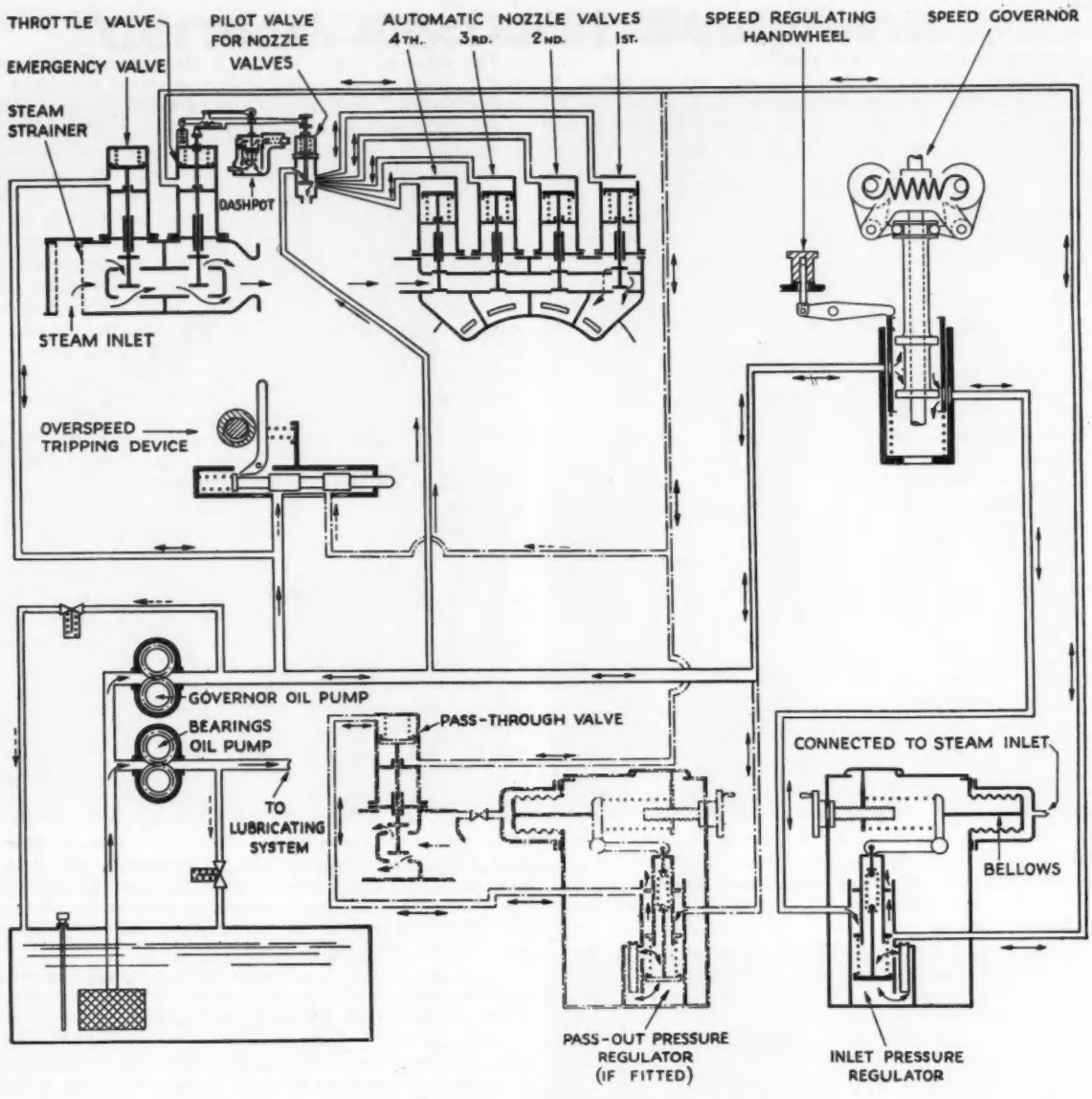


Fig. 1. Diagrammatic arrangement of inlet pressure-governing system for turbo-alternator running in parallel with public electricity supply

The accompanying diagram, Fig. 1, indicates the system of inlet pressure governing designed and adopted by W. H. Allen, Sons & Co., Ltd. A spring-opposed bellows connected to the steam supply to the turbine, controls a pilot valve interposed in the governor-relay oil system between the speed-governor pilot valve and the main steam throttle-valve relay cylinder. After the turbo-alternator is paralleled with the public supply, the speed-governor setting is adjusted by the hand mechanism until the governor is incapable of influencing the speed of the machine at normal frequencies. High-pressure relay-oil can now freely pass the speed-governor pilot valve, leaving the inlet pressure regulator-operated pilot valve to control the throttle and nozzle valves. Variations in main steam pressure, by affecting the compression of the bellows, and hence the position of the pilot valve, are reflected in variations in oil pressure under the throttle-valve relay-piston, resulting in appropriate changes in nozzle-valve opening.

Under stable conditions of steam flow the inlet steam pressure is held constant at the design figure and the turbo-alternator generates the maximum amount of power possible from the flow because the high-pressure nozzle area is correctly adjusted to suit the flow. A variation in steam flow from the boiler, by altering the ratio of nozzle area to flow, alters the inlet pressure which causes the regulator to re-adjust the nozzle area until the inlet pressure returns to the design figure.

It should be noted that the final setting of the speed governor is such that, should there be a failure of the public supply and the speed of the turbo-alternator rise unduly, the speed governor will come into operation and over-ride the inlet pressure governor, so progressively cutting off the steam supply to the turbine and acting as a pre-emergency governor to prevent the turbo-alternator being shut down.

If it should prove desirable to run a turbo-alternator on steam produced from the waste heat of water gas plant, arrangements would normally be made to make the governor insensitive to cyclical changes and responsive only to sensible changes in gas-making load, thus permitting the waste-heat boiler to act as a steam accumulator and so preventing large fluctuations in electrical power.

The application to water gas plant is, however, rather limited, as only with the very largest of installations is economic power generation possible.

Although this ground has been well covered before, a brief resumé of the advantages of automatic nozzle control will be of value, as the system is essential if full use is to be made of the heat drop provided by the inlet pressure governor.

The method of controlling the admission of steam to any pass-out or back-pressure turbine is of vital importance, owing to the limited heat drop usually available. If plain throttle governing is used, as it still is surprisingly enough by some manufacturers, the varying requirements of the turbine are met by varying the nozzle pressure. This means that at partial loads there will be a considerable drop in pressure across the throttle valve, with a correspondingly reduced pressure drop, and therefore heat drop, across the turbine itself, obviously resulting in low efficiency. High efficiency can only be realised by maintaining nozzle pressure as high as possible, and the only course is to control the steam flow by varying not the nozzle pressure but the nozzle area. In practice this is done by dividing up the nozzles into groups, each group under the control of a separate valve which operates with the minimum of throttling. The necessary fine control is effected by means of a separate throttle valve, the pressure drop across which is reduced to a bare minimum.

Fig. 2, which shows the heat-drop diagrams on a Mollier or total heat/entropy chart for a single pass-out turbine, demonstrates the virtues of nozzle control compared with throttle control. The full lines show conditions at full flow, and the dotted lines at half flow for a throttle-controlled turbine. The reduced heat drop in the high-pressure section of the machine at half flow is most apparent, although it will be noted that in the low-pressure condensing section of the turbine, due to thermodynamic considerations, there is not a great deal of difference. If we now consider the same turbine fitted with nozzle control valves in the high-pressure section, the high-pressure triangle would be identical for both full and half flow with that of the throttle-controlled machine at full flow, but the half flow low-pressure triangle would be slightly modified as shown by the chain-dotted lines. This diagram demonstrates the great importance of providing nozzle control to govern the admission of steam to the high-pressure section of a pass-out turbine, and also indicates that nozzle control is usually unnecessary in the low-pressure end of the machine exhausting to vacuum. In the case of back-pressure turbines, nozzle control is just as important as it is in the case of the high-pressure section of a pass-out machine.

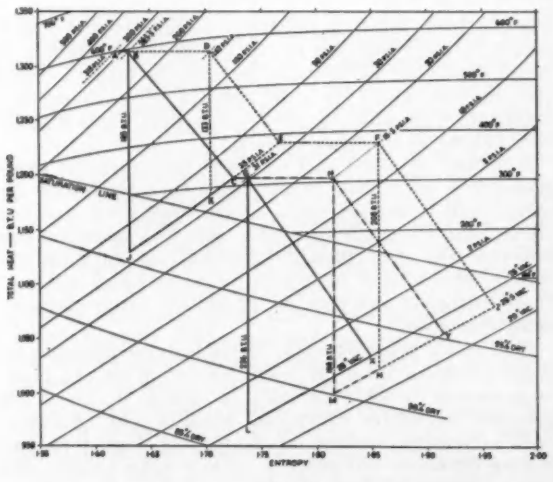


Fig. 2.

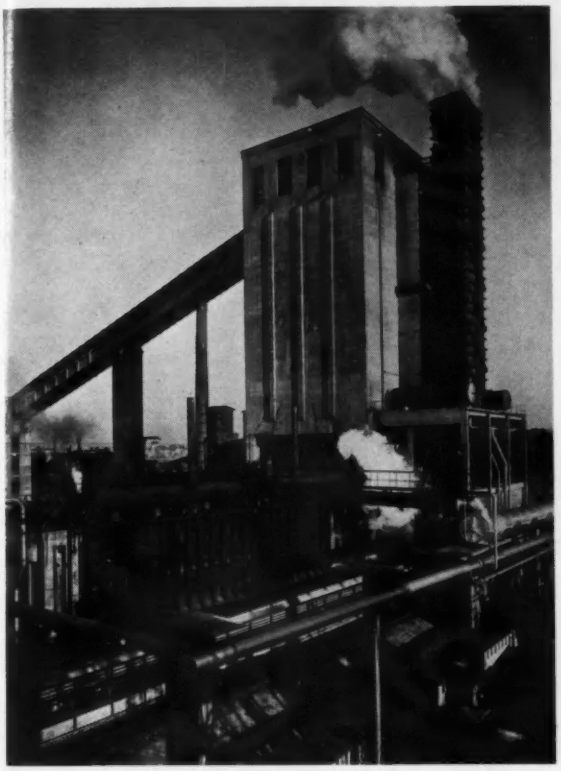
The value of nozzle control is now generally realised, but it should be remembered that in actual practice it is impossible to follow all changes of load by hand operation of the nozzle control valves, and unfortunately the invariable procedure when hand-operated valves are fitted is to open sufficient nozzles to cope with the maximum expected load, which results in considerable loss of efficiency at lower loads. It will be readily understood, therefore, that the benefits of nozzle control can never be enjoyed unless the valves are automatically-operated. All pass-out and back-pressure machines manufactured by W. H. Allen, Sons & Co., Ltd., are fitted with automatic nozzle control valves, usually four in number, sometimes six, which are operated by oil under pressure against a strong spring which tends to keep the valve open. Each valve spring is of exactly the same rate and each valve is operated in correct sequence by a separate oil port in the governor, and there is, therefore, no risk of sticking as there would be if sequential operation were effected by differing control spring rates. The provision of separate governor ports also ensures instant action of each valve with the minimum of throttling. Separate hand nozzle control valves may also be fitted.

The Central Electricity Authority is normally prepared to buy the surplus electricity which is available when a high-efficiency turbo-alternator is arranged to utilise waste heat, but it should be realised that such electricity is only of value to the C.E.A. if the power supplied to them is maintained at a constant level during the hours of appreciable load on their system. If this were not so, they would have to provide equivalent standby plant capacity with consequent increased running costs and, perhaps, the tying up of capital. What this usually amounts to is that although the C.E.A. will accept all surplus power, payment will only be made for the minimum export in kilowatts during the hours of, say, 6 a.m. to 6 p.m. on weekdays during the winter months. The amount paid, however, is usually at a rate equivalent to about ½d. per unit during the specified hours, assuming that the power exported is maintained at a constant figure, and this payment will usually amply cover generating costs.

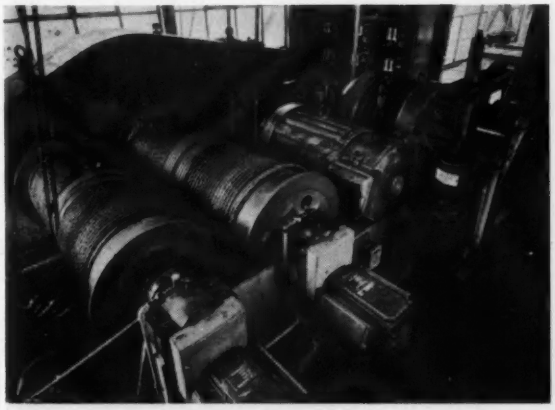
A further possibility presents itself in connection with parallel running. In most gasworks appreciable quantities of coke breeze are available, the demand for which is relatively small. Coke breeze can in fact only be used with advantage as a fuel by the larger consumers, such as steel works, and as a result it will fetch only a low price. In the case of some gasworks there may be no local demand for coke breeze which, as a result, may prove an embarrassment. It is not economically possible to transport coke breeze over any appreciable distance, and the obvious solution is to burn it on the spot and so to raise steam to supplement the output of the waste-heat boilers in the gasworks. Additional electricity can then be exported to the C.E.A., during the specified hours only, at a price which may prove far more economical than if the coke breeze itself were sold.

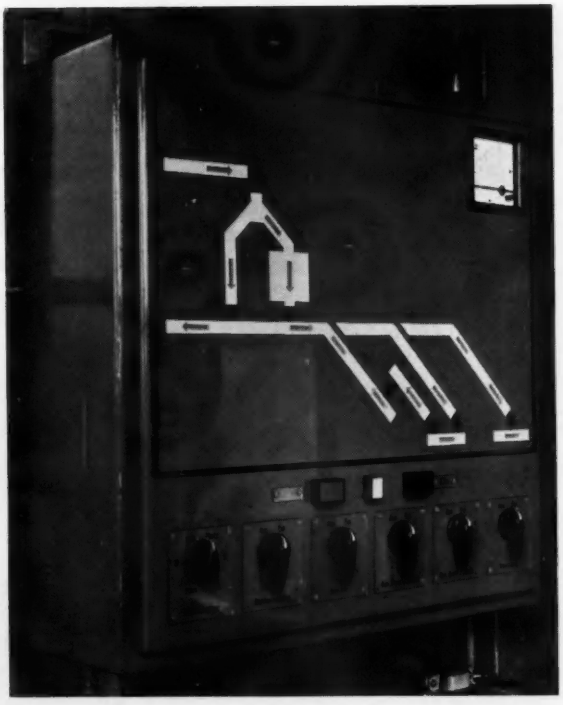
With such a system and with inlet pressure governing in operation, the coke breeze boiler pressure would of course remain constant, so that it would not be possible to gauge the steam demand by observation of boiler pressure in the usual way. This difficulty can be surmounted by providing a simple steam flow meter for the breeze boiler. The additional provision of a kilowatt meter showing the power exported to the electricity authority would greatly increase the efficiency of the plant as the indication could be maintained constant up to the limits of turbine capacity, by control of the firing rate so as to earn the maximum amount of money. The inlet pressure governor would still fulfil its primary function of maintaining high turbine efficiency.

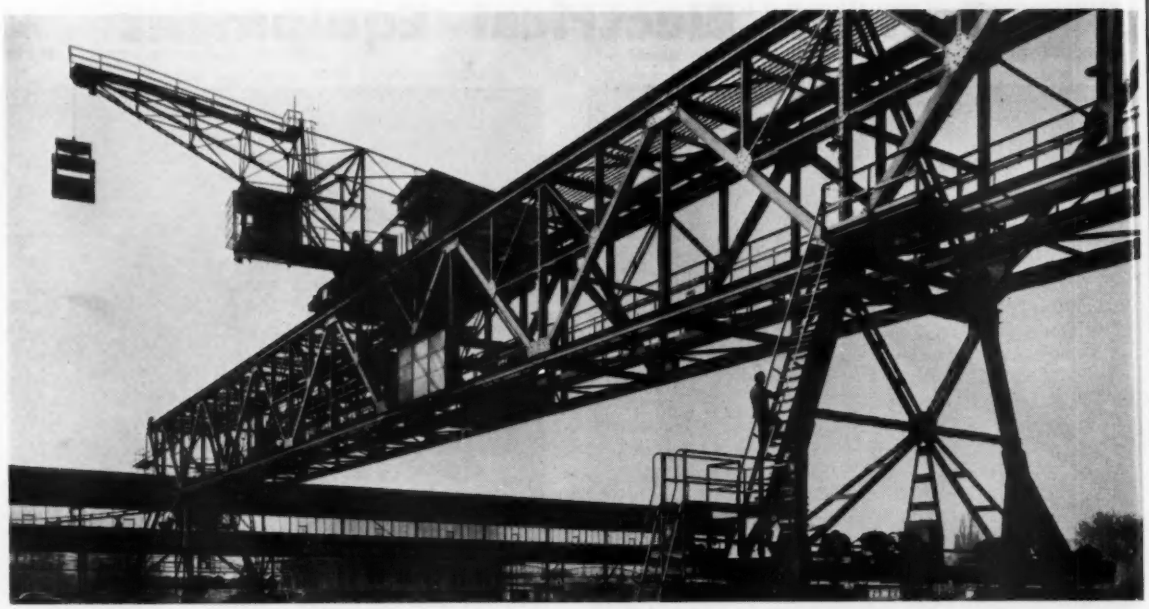
German Electrical Equipment



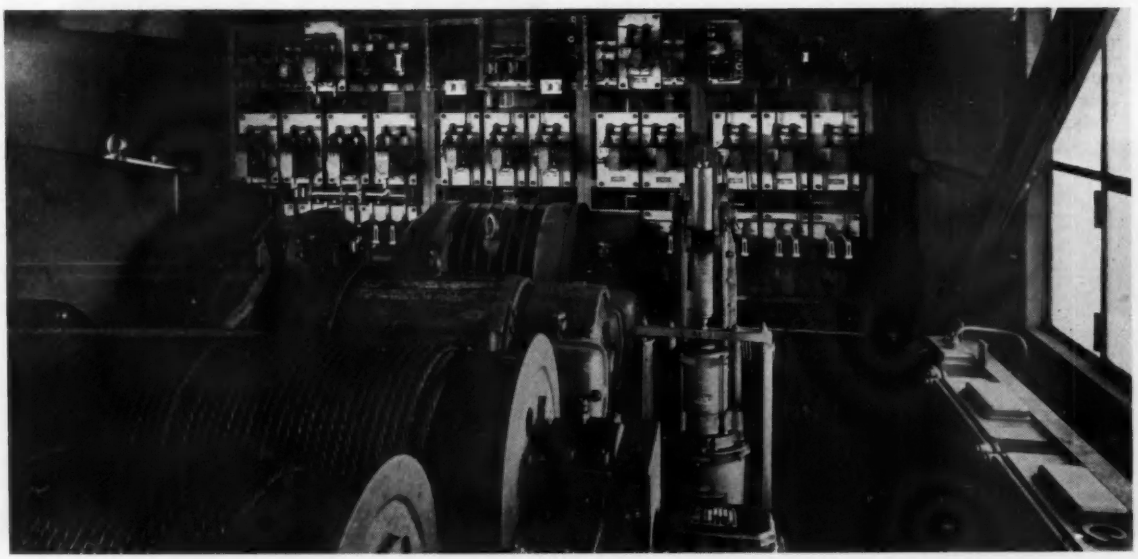
On the Continent the great majority of coal for gas production is carbonised in coke ovens. On this page are shown photographs of the Mariensdorf gasworks in Berlin which contains some of the most modern and up-to-date coking plant in Western Germany. *Above left* is shown a general view of the coke oven plant which gives a good idea of its capacity. The coal storage bunker can be seen together with the electrically driven coke guide. *Above right* is the coal handling equipment, which consists of an electrically operated grab crane for unloading barges and incorporates coal crushing equipment and a means of feeding belt conveyor equipment for the transport of coal to the coke ovens. *Below left* is shown the electrically driven winch gear which forms part of the operating mechanism of this piece of plant. In the left background can be seen the contactor control gear which works in conjunction with the remote control operated by the crane driver. In this photograph, too, the type of totally enclosed motor can be seen together with the powerful solenoid brake equipment for both motors. *Below right* can be seen the mimic diagram by means of which the operator of this coal handling plant may not only control the path followed by the coal but also see at a glance the route actually being followed.



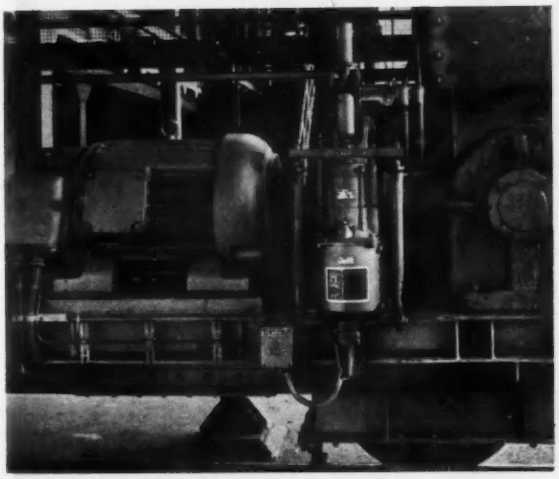


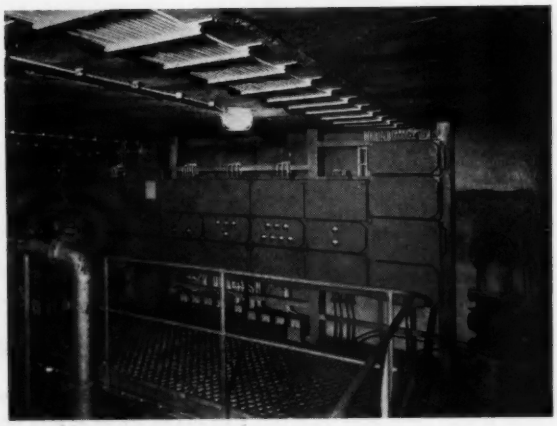


Top: A view of the coke stocking and loading plant, consisting of a steel bridge of 230 ft. span with built-in bunker and belt conveyor, slewing crane with a grab of 89 cu. ft. and a loading capacity of 70 tons per hour. The electric drive for travelling is seen at the bottom right-hand corner. *Centre:* The driver is seen in his cabin from which he has a clear view of all loading operations. He sits down to his work and his controls are conveniently placed for hand operation. The cabin is heated by electric heaters and is fitted with U.H.F. radio. *Below* is shown the winch room for operating the slewing crane. Here are the totally enclosed motors with solenoid brakes. The contactor gear shown in the background.

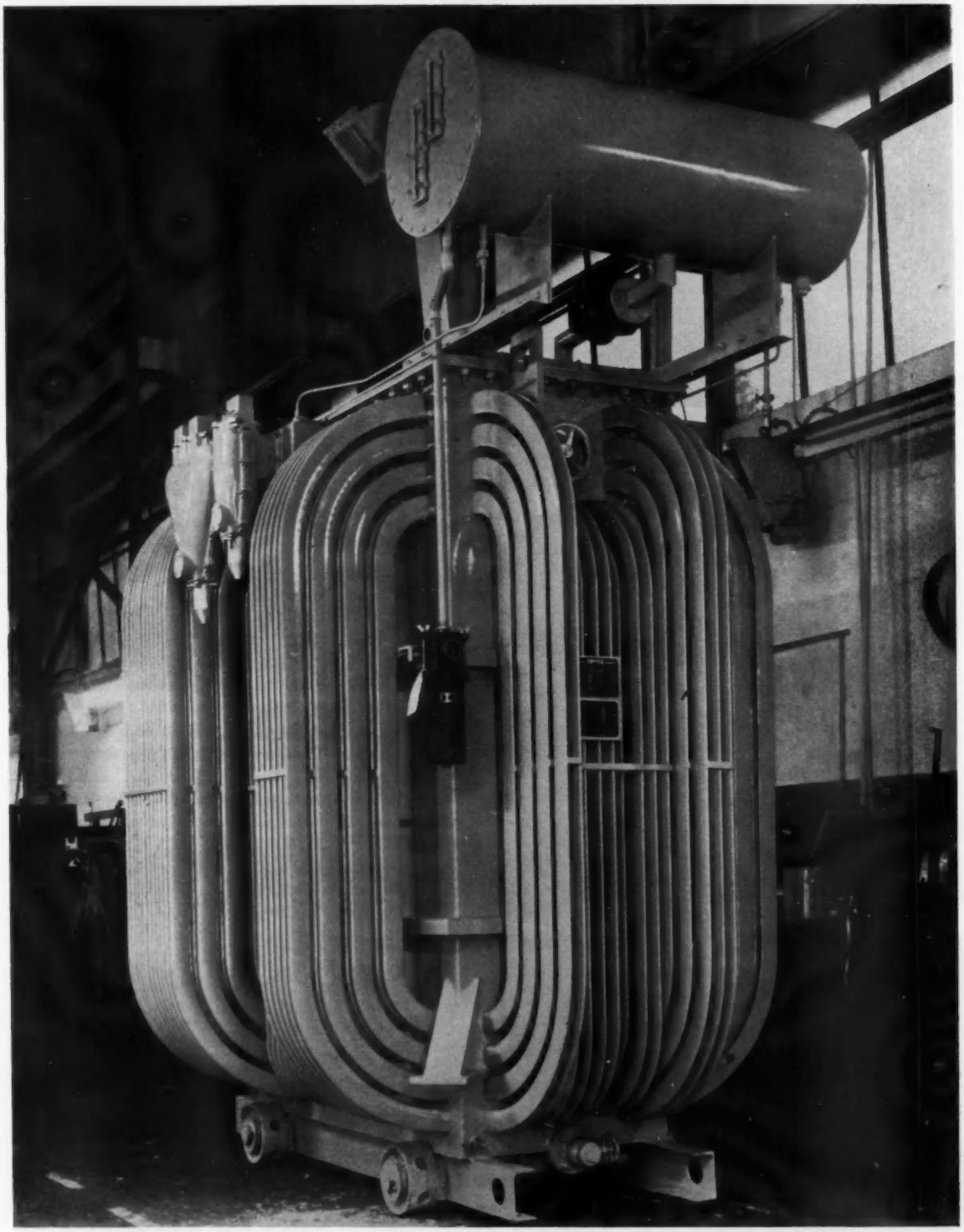


Above is a view of the interior of the driver's cabin in the coke pushing machine. As in modern practice in this country each operation to be performed in the discharge of a coke oven, involving taking off and replacing the oven doors, levelling the charge and travelling in addition to discharging the oven, is operated by a separate electric motor. The operator has a good overall view from the front of his cabin. The control equipment is substantially made and well spaced. The ammeter will be in the pusher motor circuit only to measure the 'stiffness' of an oven being discharged. In the *centre* photograph is shown the motor and drive arrangement for the travelling motor. Here, too, the motor is of the totally enclosed type fitted with a solenoid brake and connected through a reduction gear. The amount of coke dust to be found blowing about the pusher machine while discharging an oven makes it necessary to carefully protect the motor and all moving parts from its abrasive influence. *Bottom left* is seen a typical low voltage switchboard which is to be found in modern gasworks in Germany. The arrangement and type of instrument is pleasing to the eye and easy to read. *Bottom right* shows cast iron distribution equipment installed in a large pump house. This equipment has to be of a particular heavy design and capable of standing up to rough usage. The whole installation including the wiring and the lighting would appear to fit its somewhat grim location.





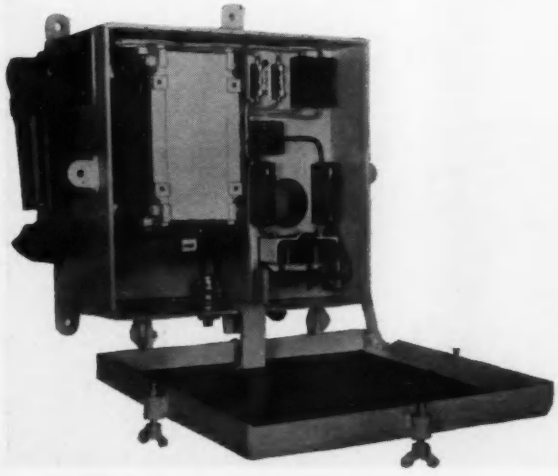
Transformers Found on

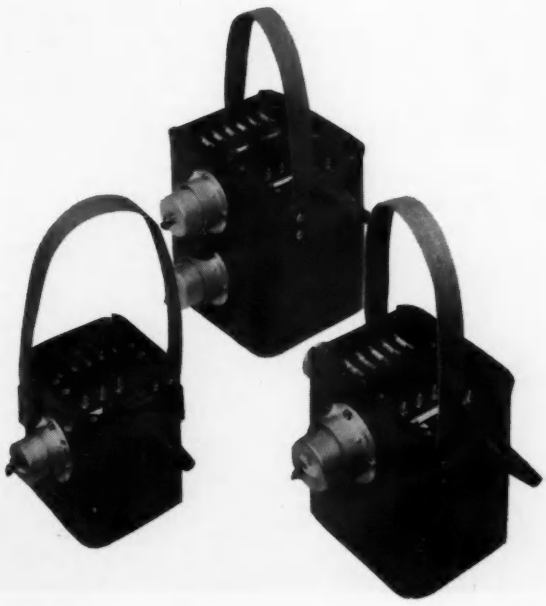


An example of a 3,000 kVA distribution transformer, built with cold rolled grain orientated steel, by Foster Transformers, Ltd. Units such as this are to be seen on gasworks in the London area.

the Modern Gasworks

Above: 5 kVA fixed location tool and lighting transformers; *below left:* special gasworks model with isolating switch; *right:* fully insulated portable types cast in resin. All equipment illustrated is by Foster Transformers, Ltd.





Floodlighting on a Coke Works

Above: Floodlighting equipment fixed to tall steel towers for lighting an extensive sidings installation. Controlled by light sensitive cells, the equipment turns on automatically at dusk and off at dawn. *Below:* The effective use of such equipment is clearly shown and fully justifies the claim of a minimum lighting standard of a halffoot candle throughout the sidings' area.

Electrical Maintenance

By W. E. G. Robinson,

ELECTRICAL ENGINEER, NORTH WESTERN GAS BOARD.

To maintain means to keep in good order, and electrical equipment may be considered to be in good order when it is capable of performing safely and efficiently all the functions for which it is designed. There is a tendency for electrical equipment to become more and more complex, the basic reason for this being the endeavour to decrease the amount of labour to operate any given type of plant. The replacement of man by a machine is making very rapid progress, but machinery will not operate for long continuous periods without some form of maintenance.

Maintenance means also the prevention of breakdowns. Industry sometimes prides itself on the way it gets its plant working after a breakdown without stopping to realise that the breakdown should never have occurred.

The British Productivity Council has published a booklet on plant maintenance which covers a very wide field. The introduction to this booklet says:—'It is a somewhat surprising characteristic of the outlook of a large number of members of management that, while they are most punctilious about having their motor-cars serviced every 1,000 miles, they do not recognise that the equipment in their factories should be subjected to scheduled maintenance.'

Variable Factors

The predominant fact which emerges from a study of the contents of this publication is that there is no such thing as a tailor-made plant maintenance scheme capable of wide-spread adoption. The nature of the industry, the type of plant to be serviced, the labour required, the scope of the application are only a few of the variable factors to be considered. The economic aspect is, of course, the main bone of contention. None but a combined engineering and mathematical genius can possibly state in advance that by spending £X on a plant maintenance scheme a firm's total output and profit will go up by a specified amount. Naturally a scheme of this nature costs money to install and money to operate, but invariably any plant maintenance will bring such advantages as a reduction in 'down' time with a consequent improved output and a higher hourly rate of working due to the absence of defects serious enough to cause a breakdown.

There are a considerable number of issues that affect the results of good maintenance. According to Nichol[2] in items of cost the condition of optimum maintenance can be stated as:—

(Cost of keeping good order) + (cost of occurrence of bad order) × (frequency of such occurrence) = a minimum.

To be true, this equation must be translated in a broad sense and its terms interpreted as follows:

The first term is made up of:

(a) Maintenance labour charges.
(b) Cost of replacement parts and consumable equipment.
(c) Interest on spares.
(d) Current charges on capital expenditure incurred to reduce maintenance.
(e) Administration charges.

The second term is compounded of some or all of the following:

(a) Repair charges.
(b) Waste of product and production material.
(c) Waste of power.
(d) Wages of idle manpower.
(e) Loss of profits on product not made.
(f) Loss of goodwill through delayed production.
(g) Injury to personnel.

The third term is determined by:

(a) Margins in design.
(b) Effects of performance of work.
(c) Situation conditions.
(d) Treatment by users.
(e) Attention from maintenance personnel.

Some of these factors will have a greater effect than others and all will not act in the same direction. This analysis is not claimed to be a complete and universal definition of the most desirable standards of maintenance, but it is rather intended to show that it is not economic to allow maintenance to resolve itself into the repair of faults and the replacement of worn parts. On the other hand it is suggested that it is usually uneconomic to spend large sums of money for the sole purpose of keeping equipment in a condition as good as new.

There are three important things that must be done before any maintenance scheme can be properly organised and show its advantages. These are:

(a) Good installation.
(b) Thorough commissioning of electrical plant before running commences.
(c) A comprehensive plant register.

Good installation has been adequately dealt with in the papers by Buxton[3] and Rimmer[4]. The commissioning of electrical plant in general covers a vast field, and is associated with a comprehensive plant register since the information required for this is easily obtained during the commissioning period.

Wide Area Covered

The commissioning of electrical plant covers a very wide area of the electrical engineering field as is shown by Richardson[5]. The behaviour of machines, when put into commission for the first time, cannot be completely forecast, but the obtaining in some cases of the initial operating characteristics, will in many respects provide an important guide to successful performance and life.

The commissioning of plant falls into two sections:—

(a) The satisfactory operation of the purely electrical side of the plant.
(b) The satisfactory construction of the mechanical side of the equipment.

It is not proposed to deal with (a) as this is usually carried out by the manufacturer, but there is a lot to be learnt while this is going on: Section (b) the satisfactory construction of electrical equipment from a mechanical point of view, is most important.

There is a remarkable tendency for manufacturers not to tighten up nuts, bolts and setscrews. A loose bolt on a set of bus bar clamps will not appear faulty under any electrical tests, but time and load will cause overheating and subsequent failure with its accompanying disorganisation. It should never be lost sight of that electrical equipment is of mechanical construction and that appropriate steps are taken to see that it functions satisfactorily in this field.

No maintenance scheme can be carried out without a comprehensive plant register. It is not possible to keep accurate records of the performance of electrical equipment without some detailed record of its construction or whereabouts.

A good plant register facilitates the ordering of spares, the keeping of spares to a minimum, and rapid replacement in times of breakdown; it also shows consistent faults.

A certain amount of clerical work is necessary initially to start such a record, but it requires very little work to keep it up-to-date. The amount of electrical equipment should not be underestimated. A typical example of the amount of electrical equipment in a works of 26.1 mill. cu.ft. per day capacity is as follows:—

271—A.C. motors (½ h.p. to 450 h.p.); 271—A.C. starters; 111—D.C. motors (½ h.p. to 90 h.p.); 111—D.C. starters; 1,200—electric lighting switches; 4—6.6kV switchboards; 14—440 V. switchboards; 11—D.C. switchboards; 3—mercury arc rectifiers; 10—H.T. and L.T. transformers; 6—electrostatic detarrers; 1,700 yards.—6.6 kV cable; 1,400 yards—main L.T. A.C. cable; 2,400 yards—Main L.T. D.C. cable; 7,000 yards—various other cables; 3—D.C. generators 250 kW.; 1—diesel alternator 100 kVA.; 2—turbo-alternators 6.6 kV 2,975 kVA.

A plant register can be kept in several forms, either loose leaf pages or in various types of card index. Both have their advantages and disadvantages. It is an easy matter to incorporate with the plant register control of maintenance and the keeping of fault records. Every piece of equipment requires means of indentification which can be in the form of numbers or letters. In most cases it is useless to use manufacturer's serial numbers, these are usually too long and involved. A plant register number must be attached to each item of equipment, readable, corrosion resisting, and generally as durable as possible. There are several ways of doing this. Numbers can be painted, or engraved on several proprietary brands of labels and either screwed on or attached by means of adhesive. Copper or brass strips with the number punched on can also be used.

Function of the Register

Maintenance control is a function of the plant register. If a card index system is used, the cards may be filed in sequential numbers, or in size or type of equipment, or grouped in plant area. A visual control system offers many advantages. This can be of the form of perforated panels, wall mounted, in which indicators are fitted. The basic details of plant areas can be put on it followed by the plant register number. Coloured indicators can then be used to show when the item is due for inspection and maintenance or whether it was missed on a particular cycle due to the plant being unavailable.

One of the biggest difficulties in routine maintenance is to make certain that all the items of equipment get maintained. For example, in a retort house it is easy enough to maintain the coal and coke handling plant as it is not in continuous use, but liquor pumps, retort house governors or waste heat boiler fans can be shut down only by arrangement and sometimes not for several weeks. A visual index system permits missed items to be picked up later. Whatever form of control is instituted this question of missed items in a rota is one of prime importance.

It is necessary to fix the time interval that must elapse for successive maintenance on any item of plant. These time intervals must vary according to the type of plant, the standard of its installation, location, age and frequency of operation. These time intervals need to be under constant review, so that they may be shortened or lengthened as circumstances and experience dictate.

Approximate Time Table

Motors
Every six weeks—complete inspection.
Every six months—grease ball and roller bearings, wash out sleeve bearings.
Every three years—dismantle completely and repair as necessary.

Starters
Every six weeks—complete inspection and adjustment.

Generators and Alternators
As for motors.

Electric Lighting Fittings
Every six weeks—clean thoroughly.

H.V. Switchboards
Every week—visual inspection.
Every year—inspection, clean and test.

L.V. Switchboards
As for H.V. Switchboards.

Cables
Every year—insulation and earth continuity tests.
Every three years—clean down and paint.

Mercury Arc Rectifiers
Every day—visual inspection.
Every year—inspection clean and overhaul.

Transformers
Every week—visual inspection.
Every year—examine for corrosion and test oil.

Detarrers
Every week—visual inspection.
Every three months—inspection, cleaning and repair.
Every year—examine rectifier for corrosion and test oil.

Many Opinions

There are many opinions on how much plant an electrician and his mate can look after. The number naturally depends on the type and condition of the plant. The two men should be able to maintain between 75 and 100 motors and starters and allied equipment.

One of the most satisfactory ways of allocating maintenance work is to take a group of plant and make the men responsible for it and to periodically change the groups so that the men in time get to know the whole works. This facilitates changing over at holidays and times of sickness. Most of the schemes mentioned so far have been used on big works. Practically all works these days belong to an administrative group and if the individual works do not have the labour force or organisation to carry out maintenance it can be done on a group basis.

Safety is a subject of prime importance but is often neglected. Maintenance electricians can show an amazing disregard for simple safety precautions, due mainly in most cases to familiarity breeding contempt. It is this attitude that causes accidents. No electrical equipment should be worked on unless it is isolated. After means of isolation have been secured, the equipment should be tested to see if it is alive, by means of a tester or other device. It should be stressed that because an isolator switch is in the 'off' position it does not mean there are no live circuits in that equipment. High tension switchgear is definitely not safe unless isolated, tested, earthed and tested again. The charging currents that can exist in high tension cables after switching off can be fatal. High tension switchgear must not be worked upon until it has been tested and earthed by an authorised person, who must then issue a 'permit to work' to the workman concerned.

In all works where there is electricity there must be notices hung in appropriate places showing methods of

dealing with electric shock. It is surprising how few electricians know how to carry out artificial respiration. All electricians and mates should be shown and given practice at least once a year.

It will be noted that in all maintenance of electrical equipment it is usual for insulation tests to be taken whether the equipment be a motor, starter, switchgear or cable. Part of the insulation of practically all electrical equipment is in the form of organic compounds which contain water as an integral part of their chemical composition, excessive temperatures which tend to dehydrate and oxidise insulation, cause it to become brittle and to disintegrate under vibration and shock.

Electrical insulation does not last for ever. It deteriorates slowly at low temperatures, and more rapidly at higher temperatures, the greater the load the higher the temperature and the shorter the life of the insulation. Available statistics (Knowlton)[6] indicate the life expectancy of insulation to be approximately halved with each 10°C. rise in operating temperature, e.g., a machine that is designed for a continuous operation of 70°C. will have its useful life halved if it operates at 80°C.

Insulation resistance is a measure of opposition offered to the current by the insulating materials. The insulation resistance is affected by dirt and moisture and is therefore of good indication of deterioration from such causes. Moisture absorbed in the winding or condensed on the surface of the insulation will result in a decrease in the measured values of insulation resistance. Therefore for insulation measurements to be significant the tests should be made immediately after shut down. The insulation resistance of D.C. machines are more sensitive to changes in humidity than those of A.C. machines. This is due to the greater number of leakage paths in the armature and fields of the D.C. machines.

Lubrication

Lubrication is a major item in the maintenance of rotating machinery. The greater majority of electrical motors have ball and roller bearings. There is no doubt that more ball and roller races fail from over greasing than under greasing. Oil and grease are the two mediums for lubricating ball and roller bearings. Grease lubricated bearings are for the most part common in the gas industry. According to Allen[7] grease lubrication of ball and roller bearings is made possible by the fact that only a small amount of oil is required. Grease is employed to a much greater extent than pure oil by the reason of its convenient form and its ability to assist greatly in sealing the housings. The operating temperature within the bearing housing, the resultant external heat and heat generated by the bearing itself are the ruling factors. Mechanical stability of the grease at the ruling temperature determines the grade to use. If too soft, the grease flows too readily in the bearing, thus impeding the rolling elements and causes churning and the generation of heat. Its efficiency, as a sealing agent is poor. If too stiff, the grease does not make sufficient contact with the working parts, which are consequently starved of oil.

When a bearing commences to rotate its moving parts plough a way through a mass of grease in the housing, hence the importance of leaving adequate space not only for the grease thus pushed aside but also for the grease introduced later, if any. The inner walls of the channel thus formed in the grease must be fairly stable, and only become deformed quickly enough to allow the moving parts to pick up the amount of oil needed.

According to Stevenson and Woosey[8], a correctly packed bearing should show an initial steep rise and fall of temperature, while the excess grease is being worked out of the bearing path. It is worth noting that with bearings above 2 in. internal diameter, and having the cage centred on the inner race, a percentage are bound to suffer undue cage wear when lubricated with grease, no matter how carefully the grease is selected. It has become almost a tradition that a ball and roller bearing should have about ¼ cu. in. of grease injected into them every three months. There is no doubt that a well designed bearing system can be left a long time without any grease being injected. One manufacturer now recommends ¼ cu. in. per in. of shaft seating diameter after every 3,000 hours running or every six months. It is necessary to repack a bearing every two to three years, as this is probably the chemical life of the grease and also there will be metal particles embedded in the grease from wear in the bearing.

It is not proposed to deal with the maintenance of different types of motors. Instructions are given by the manufacturers when the motor is supplied with all the relevant information. Control gear, with its great number of moving parts, needs more maintenance than motors, and it is usual to maintain it at the same time as the driving unit, since they are virtually a composite unit. One of the biggest enemies of control gear is dirt, and often more dirt gets into a starter when its door is opened and closed than by any other means. The maintenance of control gear is simple, and the chief thing is an examination so that parts may be replaced before trouble occurs.

Code of Practice

The British Standards Institution considers the maintenance of switchgear so important that it is issuing a Code of Practice on the subject.[9] Switchgear, by the nature of the service it renders, does not automatically make any call for that maintenance attention which, nevertheless, is necessary to ensure its efficient functioning at all times. Its normally quiescent condition does not generally draw attention to incipient faults nor to the changes resulting from general neglect. Maintenance work on switchboards requires to be carefully planned and, as it is seldom possible to shut down a complete switchboard for any length of time, the work may have to be done in stages. Unless a systematic scheme is adopted, portions are liable to be missed and may go unnoticed for very long periods. The maintenance of switchgear is no different from any other kind of electrical equipment. The oil in circuit breakers is an insulating medium and great care must be taken with it. The procedures and methods of test are described in B.S.E. 148.

These are static in operation, but this does not mean they can be ignored. Apart from mechanical maintenance, i.e., checking tightness of electric connections and the clamping screws of the windings, the major item of importance is the oil. The prime functions of the oil are to convey the heat from the coil and windings to the tank where it can be dissipated, and to provide additional insulation between these parts across which a potential difference occurs. Slignant and Lacey[10] give the requirements of transformer oil. The oil should be examined yearly and tested as laid down in B.S.S. 148.

Electronic apparatus is slowly appearing in the gas industry, and within the next decade will be in common usage. The advent of the digital computer for accountancy purposes will have much to do with this. The maintenance of electronic apparatus calls for good house keeping and carefully kept records if continuity of service is to be maintained. Electronic equipment must be de-energised and earthed before servicing. The equipment must be cleaned by blowing out with clean dry air. This will remove dust which might otherwise cause overheating by reducing the heat transfer characteristics of the components. Wiring should be inspected for loose connections; lenses, mirrors and other optical attachments for

photo-electric apparatus should be cleaned, variable and fixed resistances should be inspected for overheating and discoloured ones replaced. Capacitors should be examined for dripping wax and transformers for charred insulation and melting sealing compounds. The heater elements of valves can be inspected visually, and a valve tester used for checking drift from the standard. With proper maintenance, electronic equipment can be as reliable as any other type of electrical equipment.

No electrical department can operate without concerning itself beyond the driving unit. The mechanical end of the drive very often reflects an electrical end. A jammed conveyor will trip the electric motor starter. Repeated starting on overload may burn out a motor or starter; such occurrencies are usually classed as electrical breakdowns. There are many instances of this nature. Electricians should not have to disconnect motor couplings to prove to fitters that a pump gland is too tight. According to Mathews[11] in a typical industrial plant the proportions of breakdown were as follows.

Electrical	23%
Mechanical	29%
Operators	48%

There is no doubt that electrical and mechanical maintenance must go hand in hand. Joint mechanical electrical maintenance where it is operated is usually a great improvement, but greater attention must be paid to this aspect of the matter.

It is not possible to cover every aspect of electrical maintenance. No mention has been made of batteries, lifts, cables, the peculiarities of skip hoists, cranes, and many other matters. Maintenance is not a haphazard thing. It must be organised, and once organised must be reviewed again and again. On the whole it is regarded as an uninteresting subject, and it is true that most engineers are more interested in the plant they are going to build than the ones they already have.

Routine maintenance pays in time, money and temper. It will not always stop the unexpected from happening, but at least it will reduce the frequency with which it occurs. Plant out of commission costs money, but unfortunately costing systems do not usually show the true costs of these breakdowns. Routine maintenance pays on a private motor car, why should it not pay in our industry!

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Electric Drive for Compressors

By V. W. Press,
LANCASHIRE DYNAMO NEVELIN, LTD.

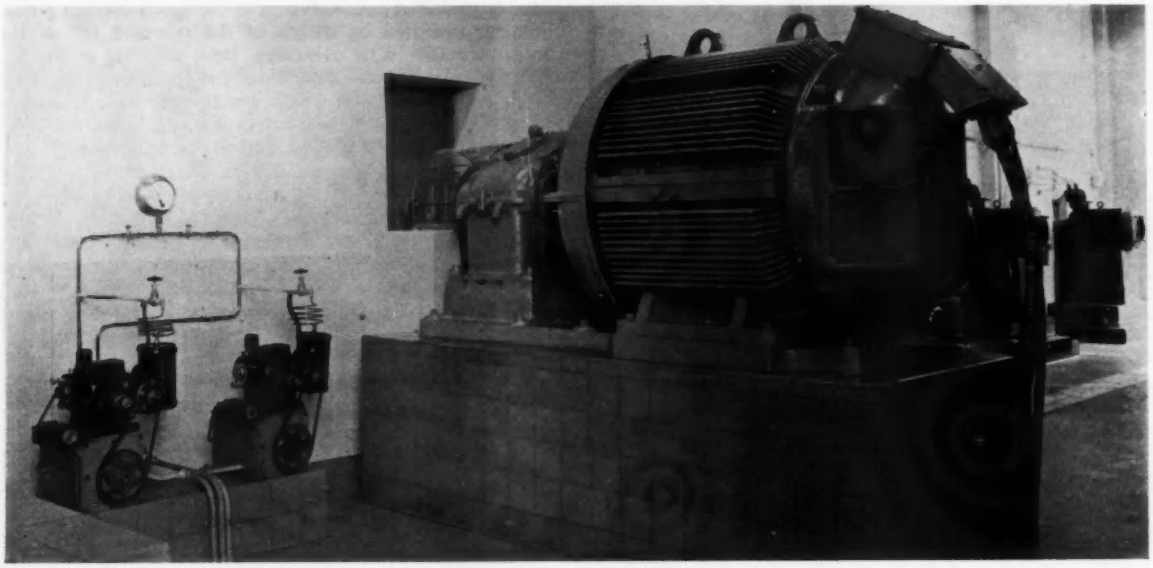

Fig. 1.—256 H.P. 360/90 r.p.m. varionic drive at Didcot.

ONE of the problems facing the gas engineer today is the increasing size of compressor plant necessary to deal with the distribution of gas in greater quantities and over longer distances, and the choice of a suitable prime mover to drive the compressor. It is rare that sufficient steam will be available for the larger machines to allow the use of a steam engine or turbine, and when electric current is generated at site it is unlikely that the generating plant will be of sufficient capacity to deal with the additional load. The choice of prime mover is therefore generally confined to an electric motor fed from the public supply A.C. grid, and to deal with the range of pressure or volume required the electric motor must be of the variable speed type. It must have a high efficiency throughout its working range of load and lend itself to automatic control in addition to complying with the special requirements for gas works duty.

A drive to meet these requirements which is increasing in favour is the grid controlled mercury arc rectifier—D.C. motor drive, due to its great flexibility to cover a wide range of circumstances. Basically the drive consists of three elements: a mercury arc rectifier of the grid control type; a shunt wound direct current motor and a speed control potentiometer. The output voltage of the rectifier is varied at will from zero to its maximum value (normally between 400 and 500 volts) by means of the speed control potentiometer, and the speed of the motor is proportional to the D.C. voltage applied to its armature. The field of the motor is energised at a constant voltage which can be supplied from the mercury arc rectifier or from a separate metal rectifier. For this type of control the power consumption is in the order of 200 watts, irrespective of the size of the drive which may be up to 1,000 H.P. or more. A typical drive is illustrated in Fig. 1.

The control circuit potentiometer is normally arranged for remote mounting and in its manual form gives fingertip control, but it can be motor operated for fully automatic working, controlled by 'raise speed' and 'lower speed' push buttons or by direct connection to auxiliary apparatus such as a pressure regulator, etc. An inherent part of the rectifier is a transformer and this has the advantage of enabling the equipment to be suitably wound for connecting to a high tension system which is frequently an advantage when dealing with large equipments which involve bringing in an electricity supply specially to deal with the compressor drives. All control gear is housed in the rectifier cubicle, normally in a dust-tight boiler plate enclosure compartment.

The motor is normally of the shunt wound type, the armature being wound for a voltage of between 400 volts and 500 volts, the supply for the field being in the order of 220 volts. For equipments up to approximately 60 H.P. the motor can be constructed in a flameproof enclosure and for larger outputs it is of the totally enclosed type, either surface cooled or forced ventilated, the drive to the compressor being through a wall box, the compressor and motor being in two separate houses. Alternatively, the motor can be of the totally enclosed pressurised type, a small fan unit being provided to maintain a small pressure within the motor, the necessary arrangements being made to ensure that the fan unit is operating before the motor can be started. In the case of a booster station remote from gas making plant it is possible to instal a motor of the screen protected type, and this type of machine is shown in Fig. 1 where the equipment is installed in a remote station.

The speed/load characteristic required depends on the type of compressor or booster installed. A reciprocating machine or a positive displacement type normally runs at a low top speed and the load is of the constant torque type. A centrifugal or fan type machine normally runs at a high top speed, and a reduction in speed causes the load to decrease by the cube of the speed. Consequently, the reciprocating or positive displacement type machines call for

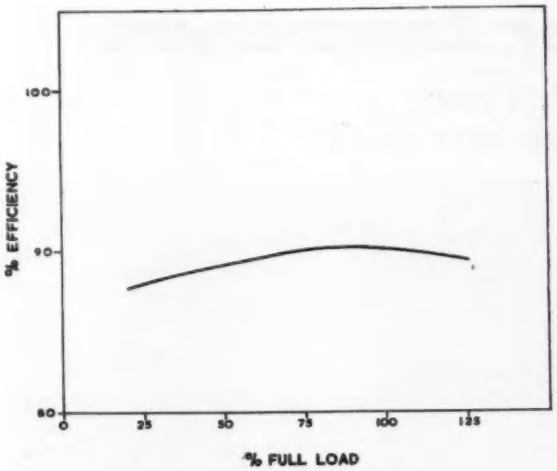

Fig. 2.—Varionic efficiency curve.

a wider range of speed than the fan type, and a speed range of up to 10/1 may be required for the former whereas not more than 2 or 3/1 is required for the latter type. As in many cases the average load on the compressor is as low as 25%, the performance of the drive at reduced speeds is of great importance, and a typical efficiency curve is shown in the diagram in Fig 2.

It frequently happens that an equipment is installed to deal with a future load requirement which may not be obtained for several years and in the meantime the equipment is to run continuously at a reduced speed and output. In such cases the rectifier drive lends itself admirably to the purpose since by a simple alteration of the transformer tappings, the output of the equipment can be reduced but at the same time the performance of the equipment when running on the reduced tapping is practically equivalent to the performance when running at full speed and load.

Numerous forms of automatic control have been applied to this type of drive. The more usual form of control is by means of a pressure regulator to control the speed according to pressure variations, and care is taken to provide damping so that the equipment ascertains that the change required is really essential and thus prevents hunting. The amount of power required to operate the control current potentiometer to vary the speed is quite small and frequently a smaller type of regulator can be used than is the case with other types of equipment. In addition to pressure regulator control and hand control, for particular applications it is possible to have the speed control potentiometer operated by means of the rise and fall of the holder together with overriding limit switches at the top and the bottom. For such cases the speed control potentiometer is mounted in a case which is of flameproof construction. Fig. 3 illustrates a motor of the 'Fankuld' type driving through a wall box, and at the side may be seen the speed control potentiometers operated by pressure regulators.

The use of a direct current motor as the rotating member of the equipment gives a number of advantages. The D.C. motor can be designed to run at very low maximum speeds and when used to drive reciprocating compressors or positive displacement type compressors, it is possible to eliminate a reduction speed gear box between the motor and the compressor.

When wide changes of load have to be catered for this can often be best dealt with by providing two or more equipments so arranged that they will operate automatically, either singly or together. A typical scheme of this type has three equipments all of which are interchangable, one becoming the master control, one being a follower and the third equipment serving as a spare unit to either of the other two. One of the equipments is selected as the master and normally runs alone under control from a pressure regulator. When the load rises beyond the capacity of one equipment the second, or follower, equipment is automatically brought into commission, the load being shared between the two equipments. When the load falls off to such a value that one equipment can cope with it the follower equipment is automatically shut down.

Drives of the type described totalling many thousands of horse power are now installed in this country and overseas giving reliable service and requiring little maintenance. The extension of the gas grid system linking up the larger works will provide many more applications.

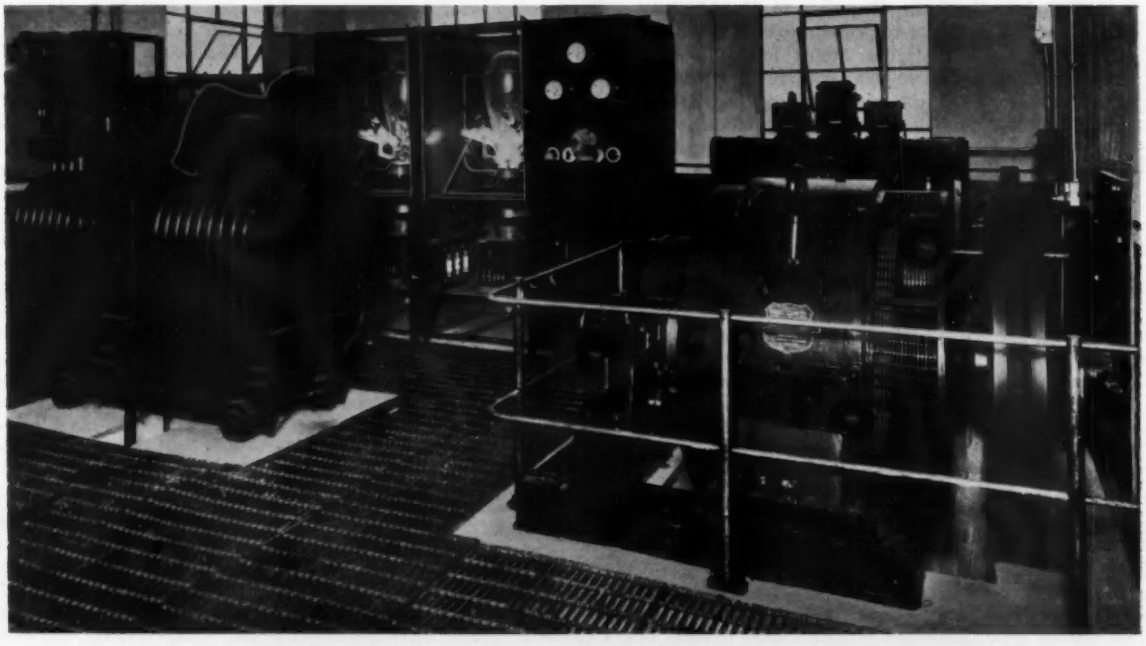

Fig. 3.—220 H.P. 1,300/215 r.p.m. 'FanKuld' motor and speed control equipment at Eastcroft.

Lighting in Gasworks

By R. L. C. Tate,
A.E.I. LAMP & LIGHTING CO., LTD.

Dust-tight visored fluorescent fittings used at the ground-floor level in a modern installation of vertical retorts. Note how the fittings are angled to cast their light on the wheel-valves.

IN order to assess its lighting requirements, it is convenient to divide a gasworks installation into four main categories, according to the nature of the work carried out and the fire-and-explosions risks involved. These categories are:—

1. Administration and office building, laboratories, changing rooms, wash rooms, etc.
2. External industrial areas, e.g., standard coke-handling plants, yards, railway sidings, stock fields, etc.
3. Retort-houses.
4. Hazardous areas, e.g., gas washing houses, pumping and drying plants, gasholders and benzole and butane plants.

Let us consider each of these in detail.

The lighting of office areas follows normal practice and presents very few special problems. Here, as in all other commercial and many industrial fields, the use of fluorescent lamps is becoming almost universal in working areas, although it is still common to find tungsten-filament lamps used in corridors and stairways. As a result, reasonably high lighting intensities are now normally found, the average illumination in a general office being in the order of 25 l/sq. ft., while in drawing offices it is often as high as 35-40 l/sq. ft.

Maintenance of lighting fittings is somewhat of a problem in a good many cases, as the atmosphere tends to be rather dirtier than that found in most commercial, though not necessarily worse than in some industrial areas. For this reason, the writer recommends the use of metal (stove enamelled) fittings and louvres where dirt is a problem, as they are rather easier to keep clean than are plastic fittings, which usually need to be treated with special fluids in order to disperse static surface charges. Where tungsten-filament fittings are used in corridors and on staircases, enclosed glass fittings are generally to be preferred to any other, and a new type of fitting recently developed in which the glassware is hermetically sealed, allowing no dust to enter, and surrounding the lamp but not necessarily enclosing it, may prove popular in this type of application.

Laboratories may need special treatment, and there are a number of dust and vapourproof fittings now on the market. Here corrosion of metal parts may be a serious problem, and fittings of the 'dust-proof' type, with plastic visors recessed in a false ceiling, may prove an effective way out of this difficulty.

Washrooms usually require enclosed fittings because of their steamy atmosphere, and it may be found necessary

to instal watertight bulkhead fittings in this class of room, especially where there is excessive condensation from walls and ceiling. In most cases, however, it is sufficient to ensure that lighting fittings are out of reach and are not in a position where they will be easily splashed or exposed to undue concentrations of steam.

Other things being equal, the choice between filament and fluorescent lighting will be entirely an economic one, and although in the past it was not always easy to justify the increased capital outlay involved in the latter system, the very great improvements in lamp life and luminous efficiency in recent years, together with a very substantial lowering of the initial cost of the lamps, have put an altogether different complexion upon it. This is shown in the table below, which refers to the standard 80w. warm-white lamp.

INCREASE IN LUMEN-HOURS PER 1s. COST OF FLUORESCENT LAMPS

Year	Price	Life (hours)	Lumen Output	1,000 Lumen hours per 1s.
1940	36/6	2,000	2,250	123
1943	30/–	2,000	2,250	150
1945	24/–	2,000	2,250	188
1947	24/–	3,000	3,040	255
1948	20/–	3,000	3,040	306
1949	15/6	3,000	3,040	395
1951	15/6	5,000	3,200	1,032
1952	13/–	5,000	3,200	1,232
1953	13/–	5,000	3,600	1,385
1955	13/–	5,000	4,160	1,545
1956	13/–	5,000	4,260	1,631

It is possible to compare the economics of tungsten filament and fluorescent lamps by the following very simple calculation based on the use of an 80w. (MCF/U) lamp.

(a) Net price of lamp (less 33%) 11s. 4d. (including Purchase Tax).
(b) Life = 5,000 hours.
(c) Average lumen output of lamp = 4,260.
(d) Average lumen output of lamp in fitting, 2,960 (70% is about the efficiency of a normal well designed industrial reflector).
(e) Total watts (including choke losses), say, 100w. (this is a little high).
(f) Total cost of electrical energy per unit, say, 1.8d.

Five thousand hours of 2,960 lumens of useful light will cost $\frac{5{,}000 \times 1.8 \times 100}{1{,}000}$ = 900d.+136d., 1 lamp=1,036d.

The nearest size of tungsten filament lamp to give 2,960 useful lumens is 300w. at 4,430 lumens (i.e., 3,100 useful lumens). Taking the same factors:

a=5s. 4d. net.
b=1,000 hours.
c=4,430 lumens.
e=300. f=1.8.

Therefore, 5,000 hours of 3,100 lumens of useful light will cost $\frac{5{,}000 \times 1.8 \times 300}{1{,}000}$ = 2,700d.+5 lamps at 5s. 4d. = 3,032d.

Since the fluorescent cost was based on 2,960 useful lumens, the equivalent tungsten cost is $\frac{3{,}032 \times 2{,}960\text{d.}}{3{,}100}$ = 2,890d., or 2.79 times as much as the 80w. fluorescent lamp.

The significant point of this argument is that one 80w. fluorescent lamp saves £7 14s. 6d. over its tungsten equivalent *during the life of the original lamp* which more than offsets the extra cost of fitting and control-gear.

The choice of a suitable light source and selection and siting of fittings for external industrial areas varies very considerably according to the nature of the installation,

This old purifier plant is totally enclosed so that dangerous concentrations of gas may easily be present when the purifiers are opened. Flameproof equipment is used.

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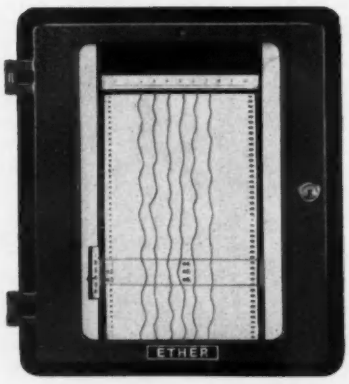

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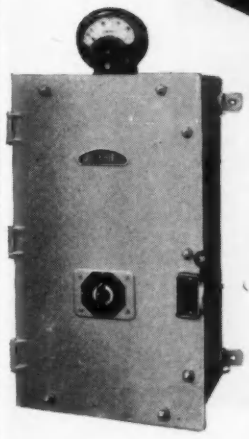

For the same installation several individual starters were supplied in heavy service cases. This special type of enclosure is frequently supplied with Brookhirst equipment. It is of $\frac{1}{16}$ in. boiler plate, with protective paint finish and special provision against dust, damp and chemical fumes, withstanding the temperature and atmosphere of gasworks.

... whether it is a complete multi-motor switchboard or an individual starter, Brookhirst meet the requirements.

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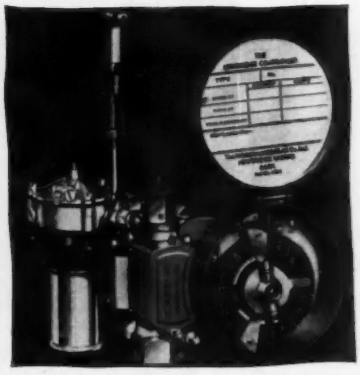

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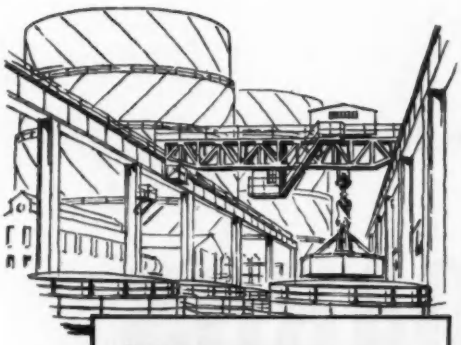

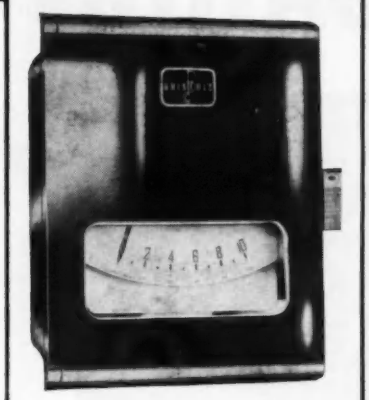

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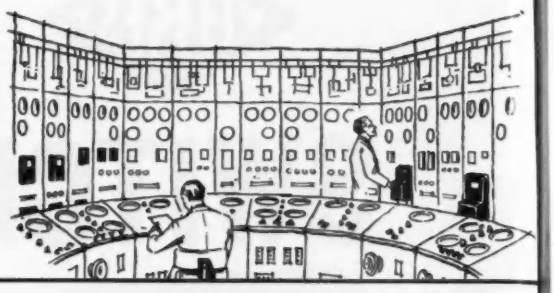

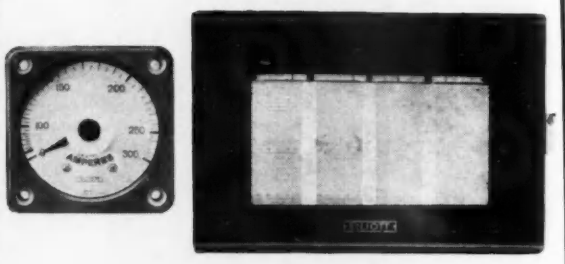

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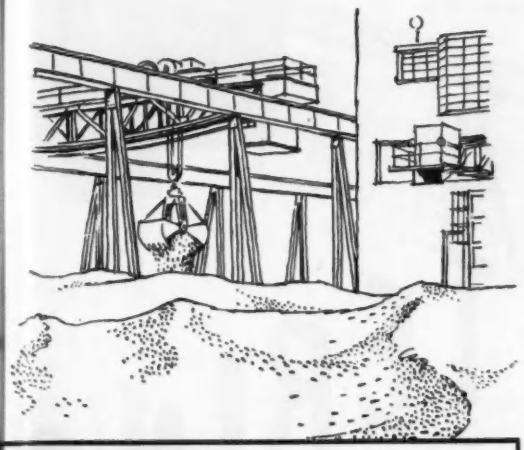

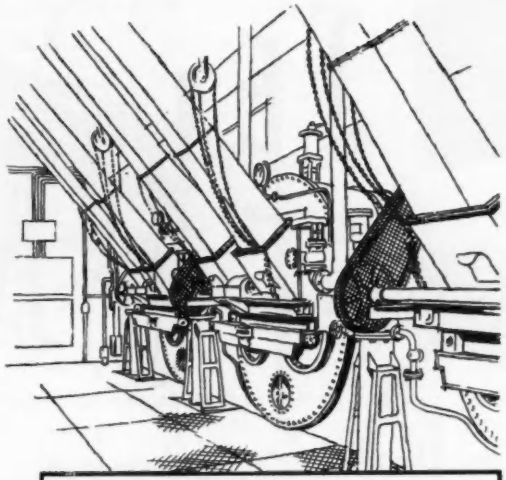

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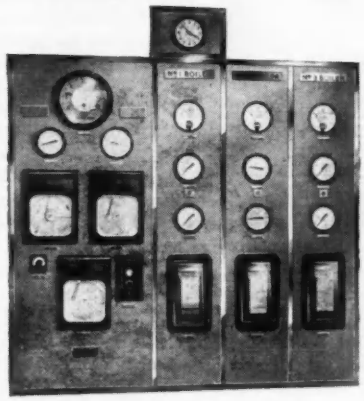

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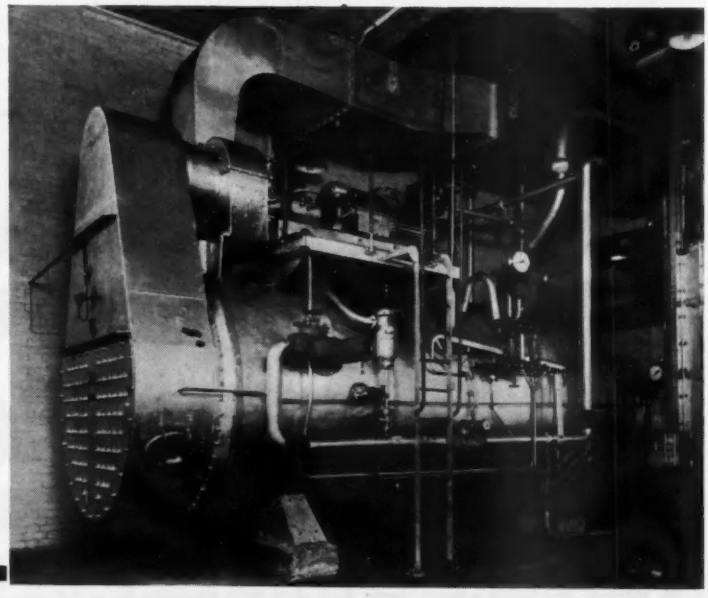

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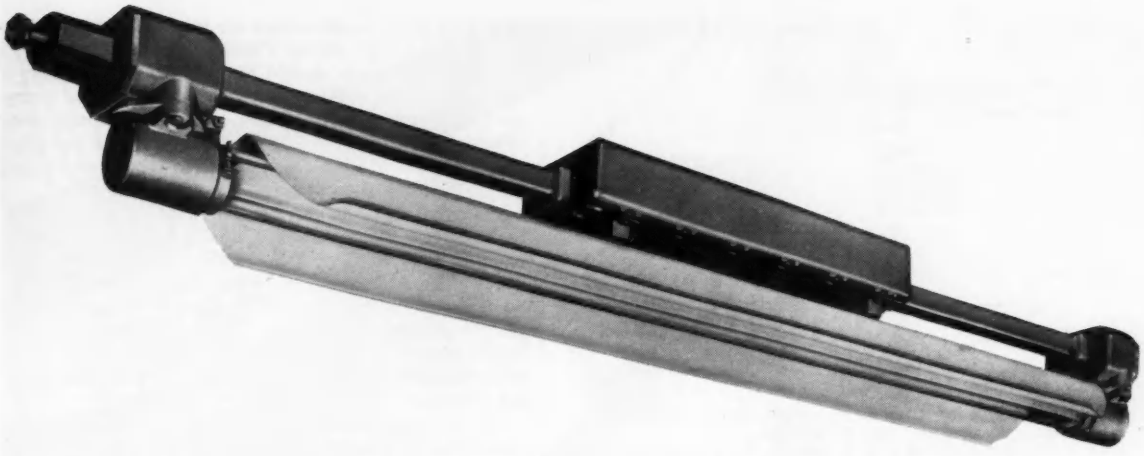


A modern flame-proof fluorescent fitting. The lamp is enclosed in an acrylic tube to guard against the danger of breakage, and a reflector is incorporated.

the proximity of railway signals, and the necessity of using dust or vapourproof equipment. All lighting equipment used outdoors must be moistureproof and of robust construction, and in some cases may have to be capable of withstanding the attacks of corrosive vapours.

For roadways and yard lighting generally it is difficult to find a better light source than the sodium discharge lamp, for its light gives especially good definition in foggy and smoky conditions, and its remarkably high efficiency makes it most economical in operation. A number of types of lantern are available, and normal street lighting practice is normally followed.

However, the monochromatic yellow of the light from sodium lamps makes them less suitable for use in working areas, especially where some colour discrimination may be required. A popular alternative is the 'MBF/U' or 'fluorescent-mercury' lamp, in which an outer jacket coated with fluorescent powders is used to add some of the missing red light to the ordinary mercury spectrum. These lamps have the same efficiency as standard H.P.M.V. lamps, and have the advantage that they can be used in the same type of enclosing fitting as ordinary tungsten filament lamps of equivalent size.

Conveyor belts, chutes, etc., need some lighting to allow inspection and minor repairs to be carried out, and this is usually provided by MBF or tungsten filament lamps in prismatic bulkhead fittings mounted on walls or stanchions. The use of tungsten filament lamps is likely to be insisted upon where the installation is close to a railway, in order to avoid the possible confusion with signal lamps which might result if sodium or mercury lamps were employed.

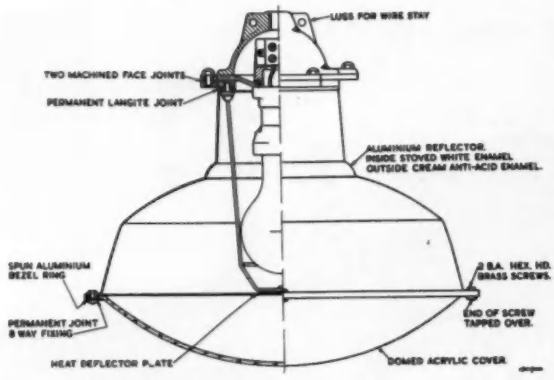
The lighting of railway sidings may present special difficulties, especially where it is difficult to arrange for fittings to be mounted at a sufficient height. The use of groups of floodlights on high towers (50-100 ft.) is rapidly ousting the class of installation where a large number of dispersive reflectors were mounted on fairly short poles, 500-100w. industrial type floodlight projectors are normally used. The technique somewhat resembles that used on football fields. Where tall buildings are available close to the siding similarly floodlights may be mounted on brackets or gantries projecting from the walls. Some extra local lighting may be needed in the vicinity of loading platforms or wagon tipplers, and here the same type of heavy duty prismatic glass lantern as is used for roadway lighting is likely to be used. But for chromatic reasons, all lighting equipment must employ tungsten-filament lamps. The writer does not know of any such installations using fluorescent lamps (MCF or MBF), but they might very well be employed for this purpose.

Coal and coke stock-yards are normally lighted in a similar manner (i.e. by floodlighting equipment mounted on poles or on adjacent buildings) but in some cases difficulties may be experienced owing to local conditions (e.g. it may not be easy to get a supply into the field). Small fields may be floodlighted from the under side of the conveyor or transportable equipment may be used. Here some difficulty may be experienced owing to trailing cables. Such equipment is usually fed from a 110 v. supply centre tapped to earth.

Areas where a very dusty and corrosive atmosphere is likely to be found are retort houses and coke screening plants. In the former the atmosphere at the upper levels is likely to be hazy, and where vertical retorts are used there are many obstructions which necessitate a large number of lighting fittings to ensure adequate penetration of the light into the areas between retorts, etc. The discharge of tar-laden fumes when 'top-rodding' is carried out will lead to very rapid deterioration of reflectors or cover glasses, especially where benches are mounted end to end, necessitating a central row of lighting fittings. In such situations the use of reflector lamps may be worth consideration, as by this means deterioration of the reflector is impossible, but it is probable that difficulties would be experienced owing to deterioration of lampholders. In an example seen by the author, however, open standard dispersive vitreous enamelled reflectors were used in this position, and these had to be cleaned twice weekly. In such a case, reflector lamps might well prove quite satisfactory. The high ambient temperatures found in these areas make the use of fluorescent lamps inadvisable, as their efficiency is sensibly reduced, a drop of 20% of light output occurs at ambient temperatures of 150°F. Strong rising currents of air are unavoidable in retort houses and will carry dust and dirt with them. Consequently frequent and regular maintenance of lighting fittings is essential, and it is standard practice to employ a small team of men who do little else but replace lamps and clean and maintain fittings.

Galleries and staircases must be well lighted in order to avoid the danger of operatives slipping or falling against hot surfaces, and for this purpose heavy-duty prismatic glass bulkhead fittings are usually employed. At the lower levels of vertical retort-houses, special dustproof fluorescent fittings can be angled towards the coke discharge ports to give five to six footcandles on the wheel valves and between the retorts. General lighting can also be produced by fluorescent lamps as at this level temperatures are not likely to affect light output or cause deterioration of control gear and it is recommended that a cool colour, such as 'daylight' should be used in order to emphasise aluminium paint on retorts, flues, etc.

Horizontal retort houses present even greater corrosion


LUGS FOR WIRE STAY
TWO MACHINED FACE JOINTS
PERMANENT LANGITE JOINT
ALUMINIUM REFLECTOR. INSIDE STOVED WHITE ENAMEL OUTSIDE CREAM ANTI-ACID ENAMEL.
SPUN ALUMINIUM BEZEL RING
2 B.A. HEX. HD. BRASS SCREWS.
END OF SCREW TAPPED OVER.
PERMANENT JOINT 8 WAY FIXING
HEAT DEFLECTOR PLATE
DOMED ACRYLIC COVER

A dust-proof type industrial fitting using a standard dispersive reflector with acrylic visor. This type of fitting is less commonly used than bulkhead or prismatic refractor fittings, as shown in the photograph.

problems than do the vertical type. Enclosed aluminium fittings with machined joints housing sodium lamps have been found effective, but constant maintenance is necessary as when the retort doors are opened they are surrounded by clouds of sulphurous fumes, dust and steam; 85w. lamps mounted on the back wall 25-30 ft. above the floor will give a satisfactory illumination for the purpose.

Perhaps the greatest maintenance problem is to be found in coke screening plants, where the atmosphere is more heavily laden with dust than in any other part of the installation. Here, too, there is very little headroom, and the area above the screens is likely to be much obstructed by beams and girders. For this reason a large number of fairly small light sources is preferable to a small number of large ones, and tungsten filament lamps in dustproof well-glass or bulkhead fittings are commonly employed. It must be emphasised that these conditions of restricted spaces, often enclosed by surfaces which reflect little or no light, are extremely common in both retort houses and coke handling plant, and often necessitate the use of localised rather than general lighting.

In all the situations discussed above the chief thing to guard against is corrosion. The damp, fume-laden atmosphere of the retort house is especially hard on metal fittings and only the best quality heavy-duty dust and vapourproof equipment should be used. Prismatic glass diffusers are normally used on all the fittings of this type as they have not a sufficiently wide mouth to make the use of reflectors effective. In some situations excessive heating of the fittings may lead to the breakdown of insulation of lead-in wires, and more attention needs to be given to this point by manufacturers. Toughened glass visors may have to be used in locations where very high temperatures are encountered, e.g. at the discharge point of a bank of vertical retorts.

Turning now to lighting in hazardous situations, in the fourteenth report of the Chairman's Committee of the Institute of Gas Engineers, published in 1952-53, there is a section (para. 19-54) which states:—

> 'Lighting fittings for gasworks use should be resistant to corrosion, dust, moisture and weather, should be easy to clean and their efficiency should remain high over long periods.
>
> 'The metal parts thereof should be made of cast iron, galvanised, but in some cases aluminium alloys are suitable. Fixing screws for holding together the various parts should be as far as possible of corrosion resisting materials.
>
> 'Reflectors and lamps should be totally enclosed and dust and weatherproof visors should be provided. Well-glass, bulkhead, parabolic-and-dispersive type fittings satisfying these requirements are available for tungsten-filament and high pressure mercury vapour lamps.
>
> 'Special attention should be given to the selection of fittings for hot-cathode fluorescent tubes. These fittings are very dependant for output on the condition of their reflectors. Adequate dustproofing is therefore important and they should also be designed so that the changing of lamps is not difficult.
>
> 'Wiring should be carried out in accordance with the requirements of section 9 of this code and it is recommended that ceiling-boxes, domes, etc., should be of heavy cast construction with external fixing lugs. Switches should be of robust, dustproof construction and where bad conditions may exist, watertight switches should be used. Particular care should be given to the siting of fittings to facilitate the maintenance and cleaning of lamps without danger.
>
> 'In dangerous zones (see section 3,-38) fittings and accessories should be of flameproof construction certified for Group III gases and the installation should be made in accordance with the recommendations contained in section 3.'

Where there is danger of explosion, however, as in gas pumping and washing plant, benzole and butane plants, flameproof equipment must be used.

Gases are divided into four classes according to their inflammability and explosion characteristics. These classes are shown in table 2: more precise details can be found in BSS.229, 1946. It will be noted that coal gas requires equipment conforming to Class III, while most of its derivatives are in Class II. Consequently it is normal practice to specify Class III equipment throughout.

TABLE II

CLASSIFICATION OF INFLAMMABLE GASES AND VAPOURS

CLASS	NAME OF GAS
I	Methane
II	Blast furnace gas, propane, butane, pentane, hexane, heptane, iso-octane, decane, benzene, xylene, cyclo-hexane, acetone, ethylene, methylethyl ketone, methyl acetate, ethyl acetate, propyl acetate, butyl acetate, amyl acetate, methyl alcohol, ethyl alcohol, butyl alcohol, ethyl ether, iso-butyl alcohol, amyl alcohol.
III	Coal gas
IV	Acetylene, carbon disulphide, hydrogen

Flameproof equipment commonly takes one of two forms: That in which the outer casing is made in such a way that it will withstand an explosion inside the lamp chamber, and the joints are long enough to quench the resultant flames before they reach the outer air, and that in which the whole system is pressurised, so that an explosive gas mixture cannot enter the fittings. Such systems are normally pressurised by air to a few inches of water. It is, of course, essential to arrange for the air intake to be remote from any point where inflammable gases are likely to penetrate. Installation and maintenance of the pressurising system is likely to add to the complications of the installation, and it is more usual to employ the flameproof type of equipment.

Another method of protection is to mount lighting equipment outside the danger area, and allow the light to pass into the building through sealed, gas-tight windows. This method has the advantage that normal lighting equipment can be used, but care must be taken to ventilate the enclosures in which the fittings are mounted. Isolation of

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The **NEW WORLD** Convector is flueless and may be connected to gas from either side in any convenient position.

The outer casing and front panel are finished in a choice of colours — see below — whilst the expanded metal grille and lighting hole are chromium-plated.

All Gold
Gold outer case with cream front

All Bronze
Nubian outer case with cream front

Height: 26 in. **Width:** 18¼ in. **Depth:** 5¾ in.
Gas Rating: 7,500 B.Th.U/hr.

MECHANICAL HANDLING PLANT

for Coal Coke Oxide

backed by

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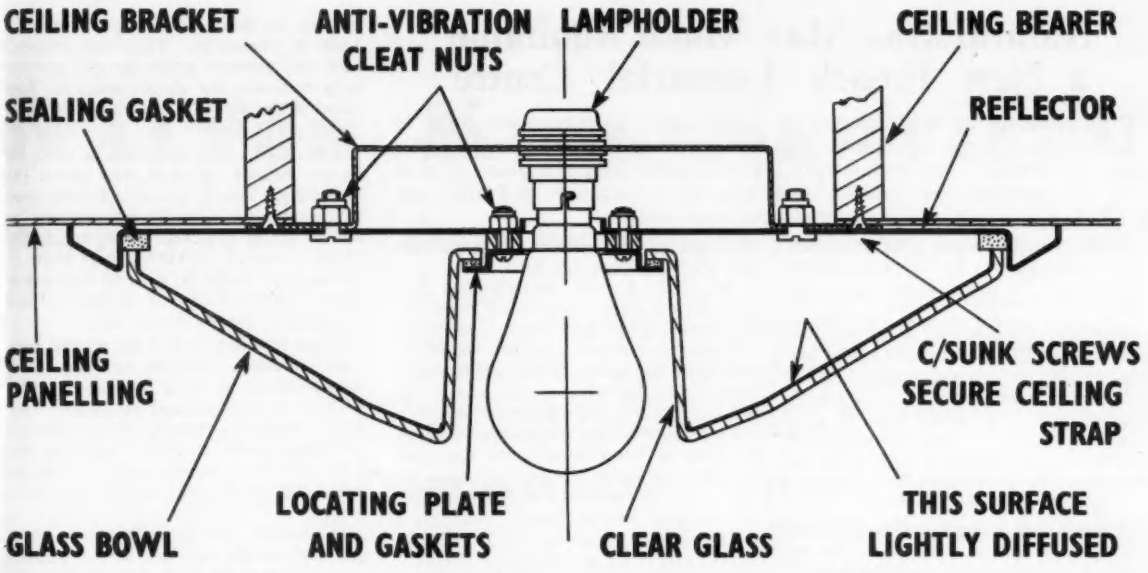


The 'Cleanlight' fitting is suitable for office corridors. Maintenance is extremely simple as the glass enclosure is completely sealed and cannot 'breathe' and draw dirt inside it.

areas where explosive gases are likely to be found is a common expedient to reduce the number of flameproof fittings required: In pumping houses, for example, the motors can be isolated from the boosters by a wall, through which their shafts pass in flameproof wall-boxes. All doors from the booster house must lead into the open air to prevent the risk of explosive gases passing into the motor-room.

Many old buildings have insufficient ventilation, necessitating the use of flameproof equipment, but the present day tendency is to throw as much of this type of plant open to the air as possible. In gas purification plants, for example, flameproof equipment is normally required, but where the purifiers are open to the sky, or housed in an openwalled building like a dutch barn, normal vapourproof fittings with machined joints may be used. Corrosion is a very serious danger in such situations, however, and it may be necessary to use special stainless steel bolts and pins in order to minimise the risk of fittings or parts of fittings falling. Benzole and butane plants generally follow the normal practice for oil refineries and are located in the open air. Flame-proof fittings are normally employed, unless the fittings are situated more than 50 ft. from the installation, when dust-proof fittings may be used.

Until comparatively recently no flameproof fluorescent fittings were available suitable for both Group II and III gases (see table 2). Four types of fittings are now available, however, made by the A.E.I. Lamp & Lighting Company, the G.E.C., Simplex Electric and E. N. Mackley respectively. The last uses a 40w. circular fluorescent lamp, the other three housing 80w. 5 ft. lamps. The high efficiency of fluorescent lamps is likely to encourage engineers to use them instead of tungsten filament lamps in suitable locations, and their colour-rendering is, of course, superior to the MBF lamp which has a similar light cutput, but has the advantage that it can be used in a similar housing to a tungsten filament lamp. For technical reasons concerning the nature of the lamp itself no flameproof fittings are made for sodium lamps.

All flameproof equipment must conform to BSS.229, 1946, but in the absence of a BSS covering dust-or-vapour-proof fittings, the engineer must rely on such recommendations as that of the Gas Council, cited above and the use of equipment made by reputable manufacturers specialising in this class of work. It should be noted that not all aluminium castings will stand up to such vigorous conditions, and LM-6-M grade aluminium should always be specified.

Much valuable information is included in a paper read to the I.E.S. by Mr. A. G. Palmer and Dr. N. E. Harper (I.E.S. Transactions, Vol. XX, No. 6, 1955) and the author is indebted to this and to his colleagues in the A.E.I. Lamp & Lighting Company and to members of the North Thames Gas Board.

Electric Transmitting Gauge-Head

THERE is an increasing tendency in modern gas works to concentrate the calorimeters in one centralised control room where the calorific value of the gases from several streams can be measured separately and be continuously recorded. This applies also to the gas in the service holder which may be some considerable distance from the centre of the works; in fact, gas is frequently manufactured in two independent sections of a large works and blended some distance from each. So that all those concerned may be kept informed of any change in C.V. and to avoid long sampling pipes, the calorimeters may be placed near their sources of gas and telemetering be resorted to. By this means the centralised control room, together with interested plant operators, can be kept constantly informed of any changes that may be taking place.

To accomplish this a form of electrical transmitter is fitted to the calorimeter which passes the readings electrically to the distant point.

An example of such a transmitter is the Sigma electric transmitter head which operates on the variation of the air-gap in two iron-cored choke coils which develop a proportional voltage across a sensitive galvanometer. By displacing the axial alignment of the choke coils their impedance is altered proportionately.

Natural Gas May Make Aquitaine a New French Industrial Centre

THE presence of large reserves of natural gas in Aquitaine are likely to result in this under-developed south-west corner of France becoming a new centre of industry, apart from providing gas for other parts of France. Several 125 MW gas-fired power stations are being built by Electricité de France, one of which will supply a large aluminium reduction works.

Other projects include a fertiliser factory, manufacture of acetylene-based plastics, and a heavy-water extraction plant.

The thermal equivalent of the gas output is now 730 tons of anthracite per day, or 265,000 tons annually, but is expected to reach at least 5 mill. tons a year by 1962. It seems certain that Nantes, on the west coast of France, will receive gas *via* Langon and Angoulême, probably also St.-Etienne in the centre, and possibly Paris and the Rhône valley.

The first well in Aquitaine reached the present reservoir in 1951 at 12,700 ft. depth. The unusually heavy reservoir pressure of 9,500 lb. per sq. in. overcame the weight of the drilling fluid, and caused a blowout which lost 350 mill. cu.ft. of gas before control was effected, after nearly eight weeks.

As the gas contains 15% of H_2S, it has a corrosive effect on ordinary steel tubing, particularly at high velocities. The first well was, therefore, abandoned and cemented up. Tubes of special steel were imported and used in another hole, drilled several thousand yards away in 1953, but, again, corrosion stopped output, this time after ten days.

By 1955, French metallurgists had developed a steel which could resist this corrosion, and the same hole was re-tubed in 1956. Another six wells drilled in the same year established the reservoir as one of several square miles, in a thick, porous, hard limestone.

Calculation of the pore volume within the area of these seven wells indicated that the volume of gas available was 4.4 bill. cu.ft. More wells now being drilled, if they give positive results, may raise the estimated reserves by 100% or 200%.

The difficulties of extracting the H_2S from the gas commercially were overcome at the same time as the metallurgical difficulties, so that by May, 1957, 35 mill. cu.ft. of raw gas were flowing daily into the refinery at Lacq, and 23 mill. cu.ft. of purified gas were flowing out of it, at a calorific value of 1,010 B.Th.U. per cu.ft.

The second stage of the refinery, expected to be completed by June, 1958, should have four times this capacity. The gas leaves the wells at a temperature of 140°C., and a pressure of 7,000 lb. per sq. in., but enters the refinery at 1,000 lb. per sq. in. This high temperature and pressure make the gas particularly corrosive, for which reason the flow speed in the wells must be kept down to 10 ft. per second.

The cost of H_2S extraction is paid for by the sulphur obtained, now about 140 tons daily. This may enable France soon to become an exporter of sulphur, as well as saving the dollars with which her 220,000 tons of annual imports have to be bought. Some 30 tons of high-grade motor spirit and 20 tons of propane and butane are also produced daily.

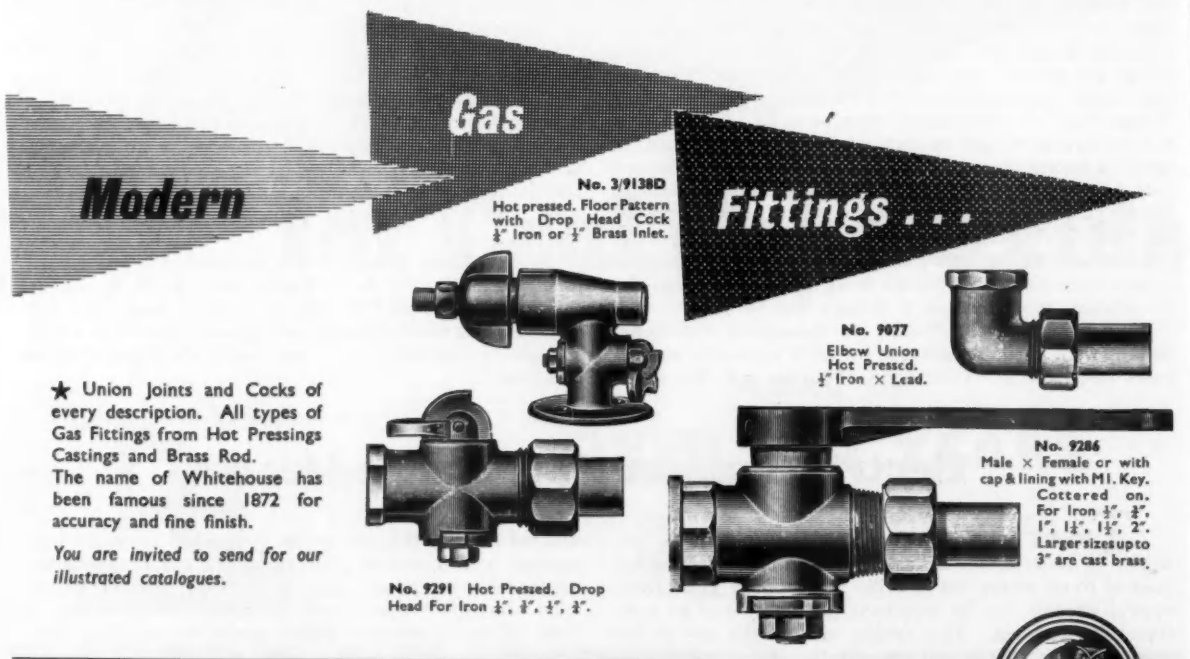
These by-product outputs should have been increased five times by June, 1958, with increases of up to 20 times by 1962.

Other news of natural gas comes from Texas, where a natural gas producing processing plant is to be built in San Juan, County Utah. It will process gas from the Aneth field in the San Juan basin.

In Canada, Northern Ontario, natural gas distribution facilities in the Kenora area will be ready to operate by November 1. This is the target date for Trans-Canada Pipe Lines to deliver gas to the area, making it the first in Ontario to be served by the line.

In Australia, Colonial Gas Holdings, in association with Australian Gas Light Company of Sydney, has formed a new company to distribute liquid petroleum gas for use as fuel and power.

The company, known as Thermal Traders Proprietary, has been registered in Canberra.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Applications stating age and experience should be sent to Staff Controller, North Thames Gas Board, 30, Kensington Church Street, London, W.8, quoting reference GJ/486.

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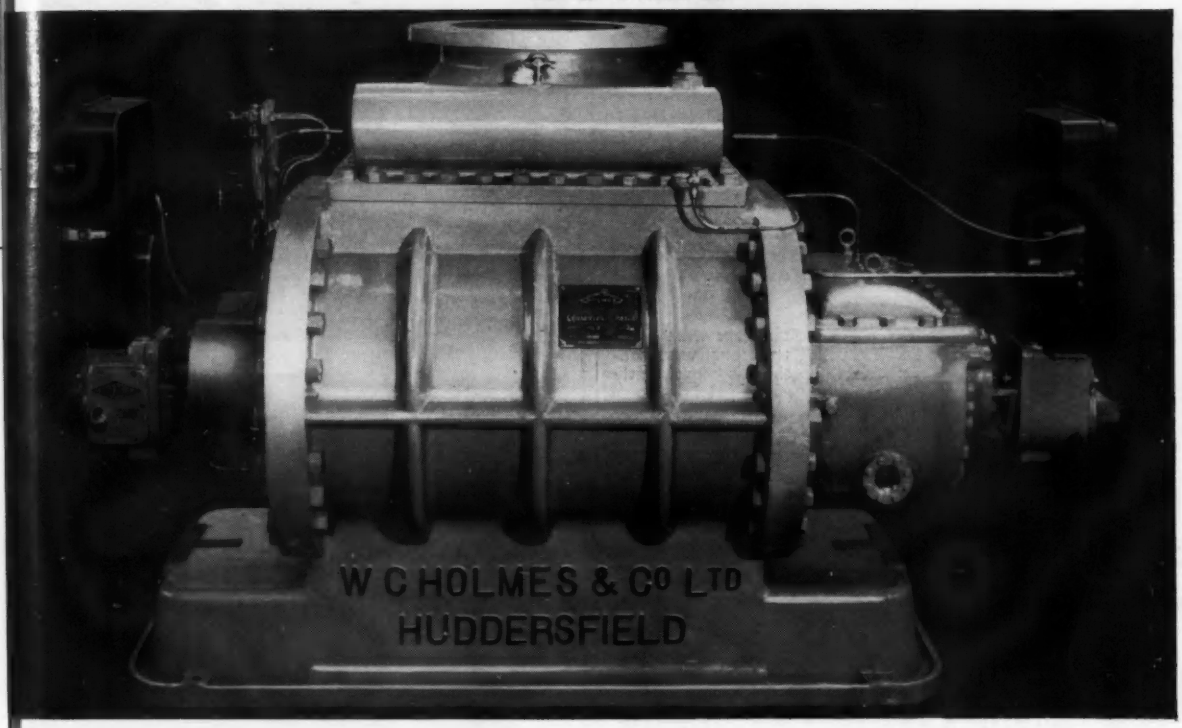

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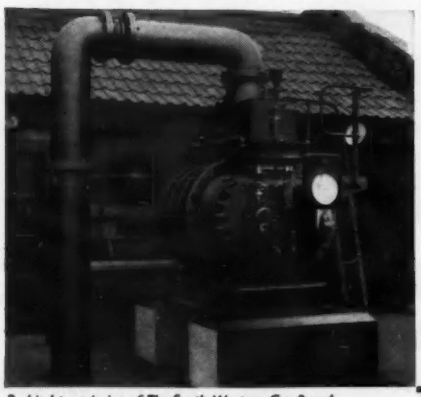

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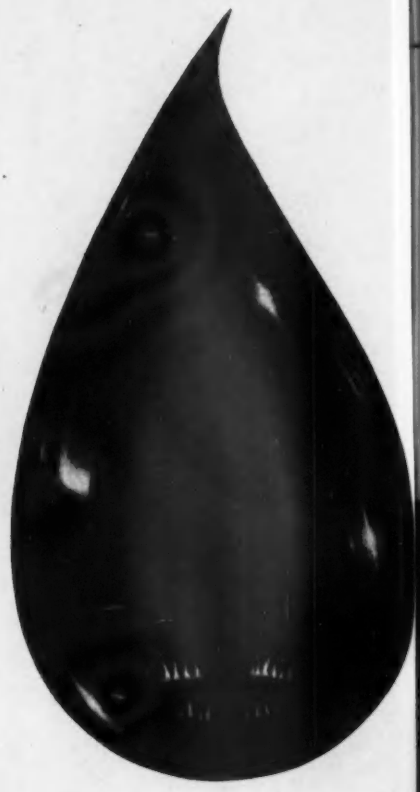

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